IDO-19301
CEND-1007

SL-1 RECOVERY OPERATIONS

JANUARY 3 THRU MAY 20, 1961

JUNE 30, 1961

CONTRACT NUMBER AT(10-1)-967
U.S. ATOMIC ENERGY COMMISSION

NUCLEAR DIVISION

C·E COMBUSTION ENGINEERING, INC.

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COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION
IDAHO FALLS IDAHO

GENERAL VIEW—SL-1 FACILITY

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SUMMARY

The SL-1 facility was a boiling water reactor demonstration plant for providing electrical power and process heat for remote military bases. The nuclear power plant, located at the National Reactor Testing Station, generated 300 KW of electrical power and 400 KW of heat from a 3,000 KW reactor.

The SL-1 plant, designed and constructed by the Argonne National Laboratory, was operated by Combustion Engineering, Inc. under contract to the Idaho Operations Office of the Atomic Energy Commission. The plant had been operated by military crews under Combustion supervision since February, 1959 for the purposes of obtaining operational and maintenance experience, training of military operators, and testing components for more advanced portable low power reactors (PL). A PL Condenser was installed in September, 1960 and was undergoing performance tests. A replacement core and control rod drives (PL type) were scheduled for installation at SL-1 in May, 1961.

The plant had been operated for approximately two years (40% of design core lifetime) when a nuclear excursion occurred on January 3, 1961. Three operators (all military personnel) who were reassembling the control rod and drive mechanism following a ten day plant shutdown period were fatally injured.

During the period from January 3 to January 10, a NRTS disaster plan was effected for recovery of the three casualties and for an assessment of the SL-1 reactor shutdown condition. A radiation survey failed to detect the presence of neutrons; thus, it was inferred that the reactor was not critical. Early observations of the water on the reactor room floor and of steam blowing from the condenser cooling air exhaust indicated that some amount of water was expelled from the reactor vessel during and after the excursion. The physical damage to the core and the location of control rods were unknown. No conclusion, therefore, could be drawn about the mechanism which shut down the reactor. Until additional information was available about core geometry and presence of water in the reactor vessel it was assumed that disturbance of the core structure might result in another nuclear excursion.

Based upon this state of knowledge the next operational phase, designated "Core Deactivation" was undertaken with the objectives of establishing core reactivity condition and adding negative reactivity if required. An approved deactivation plan which was initiated on January 17, 1961, included the following steps:

1. Make radiation survey of the site and support buildings

2. Install neutron and gamma detection and alarm instrumentation in a suitable location to monitor subsequent activities

3. View the top of the reactor vessel head to determine the access available for penetration

4. View inside the reactor vessel to determine the condition of the core and the water level optically

5. Determine the water level mechanically if unseccessful in Step 4.

6. Add poison solution to reactor to reduce reactivity and to provide shielding

Because of the concern that a second nuclear excursion might occur, deactivation operations were performed with remote handling equipment operated from outside the reactor building. Operating techniques were based upon use of a light, mobile crane adapted with a specially designed traveling boom. Special remote operated equipment, i.e., movie cameras, television cameras, radiation instruments, water level and temperature probes, and vacuum sample collector, was suspended from this boom over the reactor head and into the reactor vessel.

Development of equipment and operational methods and training of operating personnel were conducted on an SL-1 facility mockup. The mockup was constructed to simulate the limitations for access into the SL-1 building and the physical condition of the reactor vessel head, and core.

To accomplish this deactivation plan, 16 operational entries were made into the SL-1 facility. An average of 14 persons took part in each entry as operators, electricians, radiation monitors, photographers, observers and supervisor. No radiation exposures during the deactivation period exceeded the authorized dose of 2.5 r/quarter.

The first comprehensive information about the reactor vessel head region and control rod positions was obtained from movie film taken on January 23, 1961. The film indicated the rupture of the shield container above the reactor vessel head and scattering of shielding material. Six of nine control rod ports in the reactor vessel head were observed to be open. Extension shafts for control rods 1, 3, 7, and 9 protruded through their respective ports. The No. 5 control rod bell housing was in place on the vessel head, thus suggesting that No. 5 control rod was in place in the core.

The No. 4 and No. 8 control rod ports were open and free of protruding objects from within the vessel. However, a shield plug which had been propelled out of the reactor vessel rested across the reactor head, partially obstructing port No. 4.

Following unsuccessful attempts to drop a television camera into the reactor vessel, a motion picture film was taken of the core on February 22, 1961. The film was taken through the open ports in the vessel head with a shield camera which was moved across the top of the reactor vessel.

The 300 feet of film obtained showed (1) substantial blast damage and radial expansion of the core structure; (2) control rods 1, 3, and 7 in core; (3) central rod No. 9 resting on top of the core; and, (4) no evidence of water.

Information on the presence or absence of water in the reactor vessel was requisite to an understanding of the reactivity condition of the SL-1 core. On February 28, 1961 a sonic water probe was lowered into the reactor vessel to the top of the core with no evidence of water. A water-sensitive chemical probe was lowered one and one-half feet below the core on March 29, 1961 and again to the bottom of the reactor vessel on April 15, 1961 with no evidence of water. The latter penetration of the core with the chemical probe was recorded photographically.

With the absence of water in the reactor vessel and the shutdown condition of the reactor clearly established, other entries were conducted to obtain additional information on core damage.

Viewing of the core structure through ports 4 and 8 was performed with a television camera and with a miniature still camera. A total of 400 feet of movie film was taken of the television monitor on May 17, 1961. Seventy still pictures were produced during entrance in May 11 and 19, 1961 which covered approximately 60% of the core.

A sample of melted fuel alloy was recovered on April 20 and a radiation survey of the reactor room floor and ceiling was performed on May 3, 1961.

On March 28, 1961, Combustion proposed a plan for the reactivity reduction and shielding of the SL-1 core by the addition of a 25 gram per liter solution of boric acid to the reactor. The addition of boric acid was to be made under the same controlled conditions used in approaching criticality by raising water level in a water moderated core critical experiment. This approach was based upon the then unknown geometry of the fuel and the lack of information on the presence of water in the reactor vessel.

An injection system was designed for adding the boric acid solution to the SL-1, which consisted of mixing and storage tanks, pumps and piping. The equipment was to be mounted on a flat bed trailer for transfer to the SL-1 site. Remote controls and instrumentation were to be located approximately 4,000 feet from the reactor. Procurement and fabrication of the equipment was discontinued at the time of a Commission discussion to leave the reactor vessel dry.

A plan was prepared for decontamination of the SL-1 reactor building, the removal of the core, razing of the reactor building, and decontamination of the support facilities. A concurrent effort to collect evidence on the SL-1 accident was proposed.

The plan contemplated the use of remote equipment to remove high level decontamination from the reactor building, followed by direct access to the reactor room for low level decontamination and core disassembly and removal.

I BACKGROUND TO SL-1 DEACTIVATION REPORT

A. DESCRIPTION OF SL-1 REACTOR AND PLANT

1. Arrangement

The Stationary Low Power Reactor No. 1 (SL-1) is a small, natural circulation, direct cycle boiling water reactor designed by Argonne National Laboratory to generate electric power and space heat for remote Arctic installations.

Fig. I-1 is a cutaway view of the 38 foot 7 inch diameter by 48 foot high reactor building and adjoining control room. The lower portion of the cylindrical building contains the reactor vessel surrounded by gravel shielding. The turbine generator and other plant equipment are located on the reactor room floor at the middle level (Figure I-2 and I - 3). The air-cooled condenser with its circulation fan is mounted above at the third level. The control room in the adjoining building is connected to the reactor operating floor by a stairway. An additional air-cooled condenser, provided by Combustion Engineering, Inc., is located in a separate building (Fig. I-4). Design reports on this plant are presented in References 1, 2, 3, and 4.

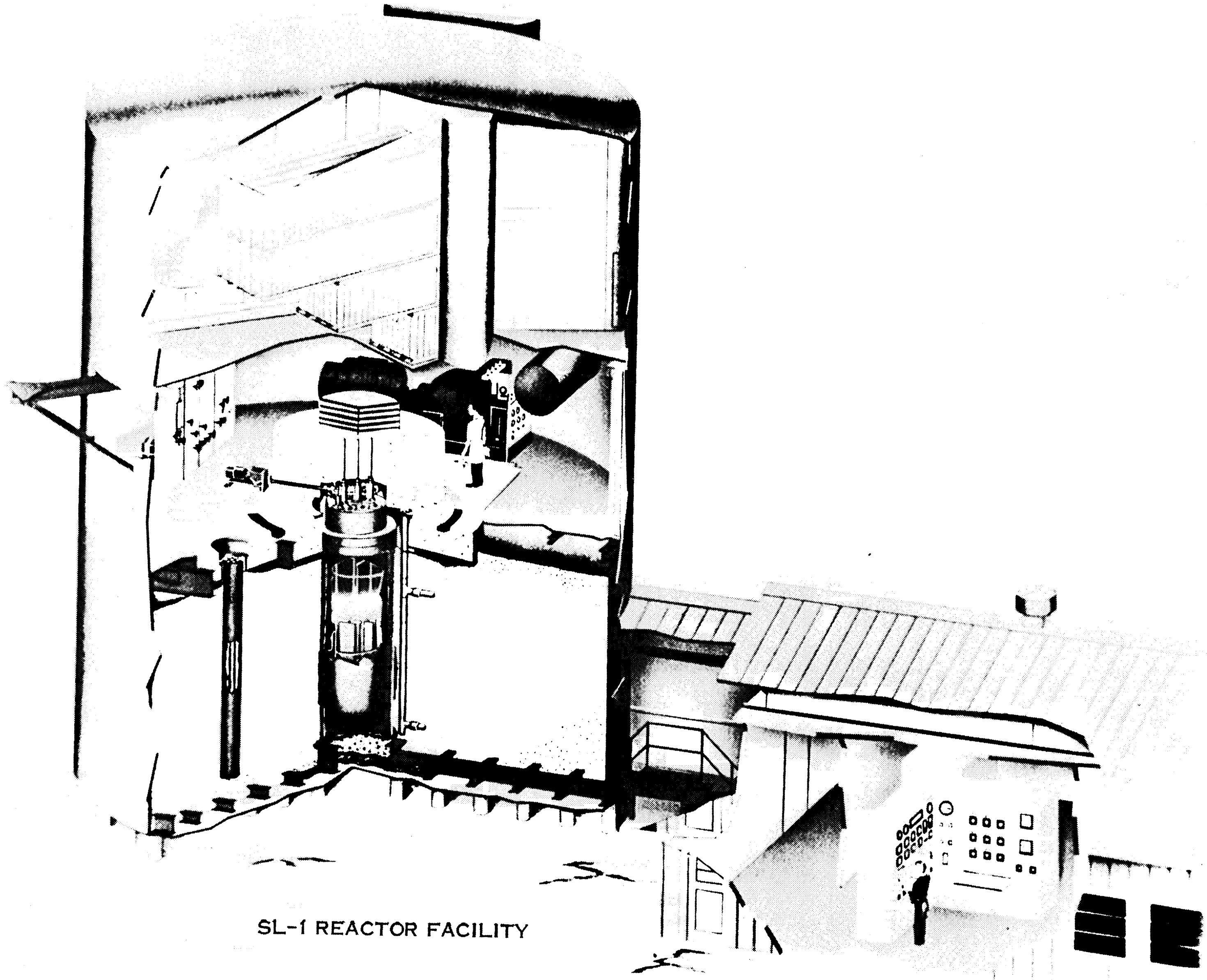
A summary of key SL-1 characteristics follows:

Reactor heat output	3 MW (t)
Steam production	9020 lbs/hr
Steam pressure	300 psig
Steam temperature	420 ^{o}F (saturated)
Turbine generator output	300 KW (e)
Space heating load	400 KW (t)
Core design lifetime	3 years
Core fuel loading U^{235}	14 Kg
Burnable poison B^{10}	22.6 Gm

2. Reactor Core

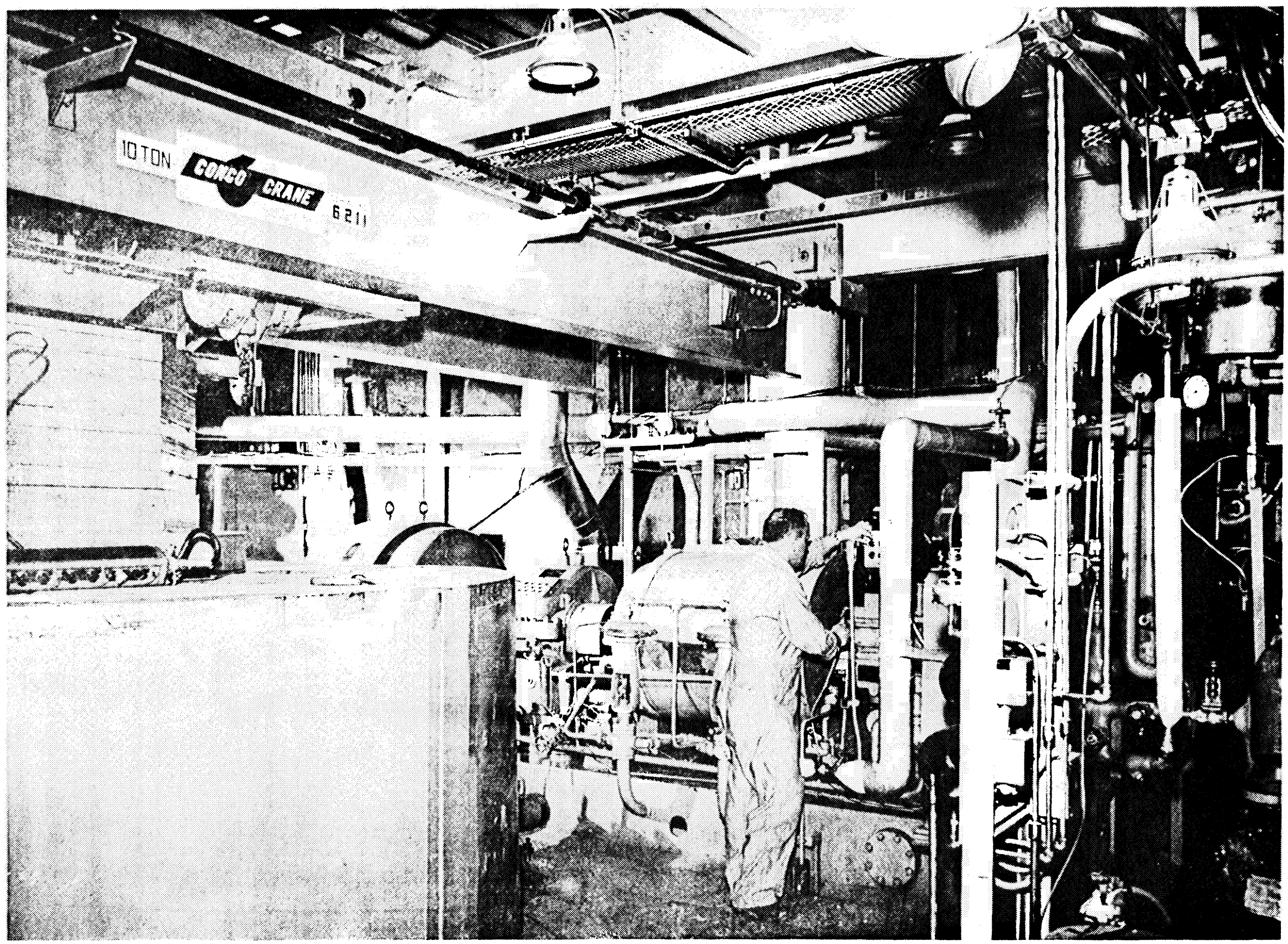
A general elevation view of the core is shown in Fig. I-5. A photograph of the reactor core looking down into the vessel is shown in Figúre I - 6.

The SL-1 core was fabricated from an aluminum-nickel alloy (Alcoa X-8001). The core structure is made up of two main components, the core shroud and the core support grid. The entire core weight is borne by the stainless



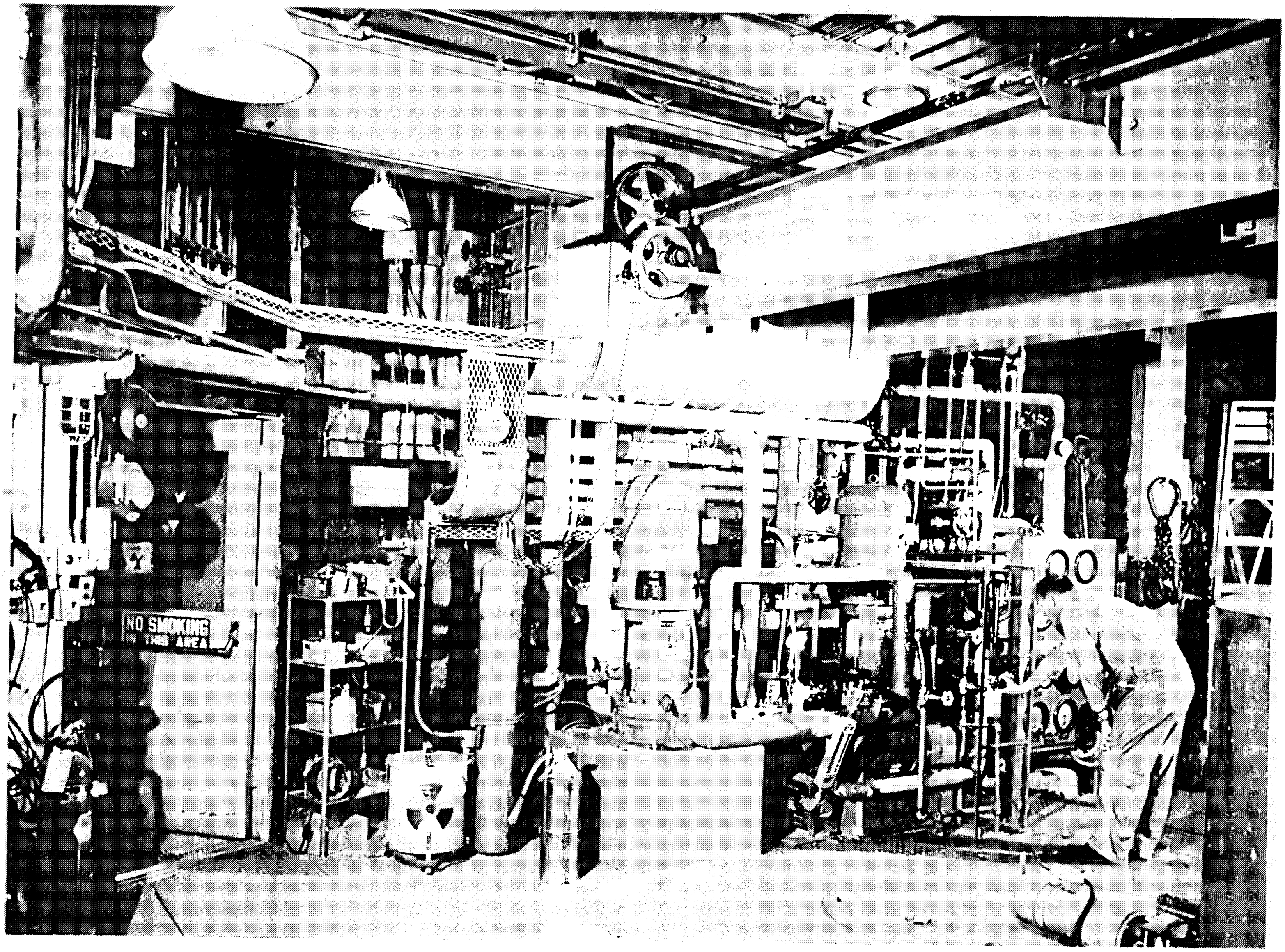
SL-1 REACTOR FACILITY

FIGURE I-1



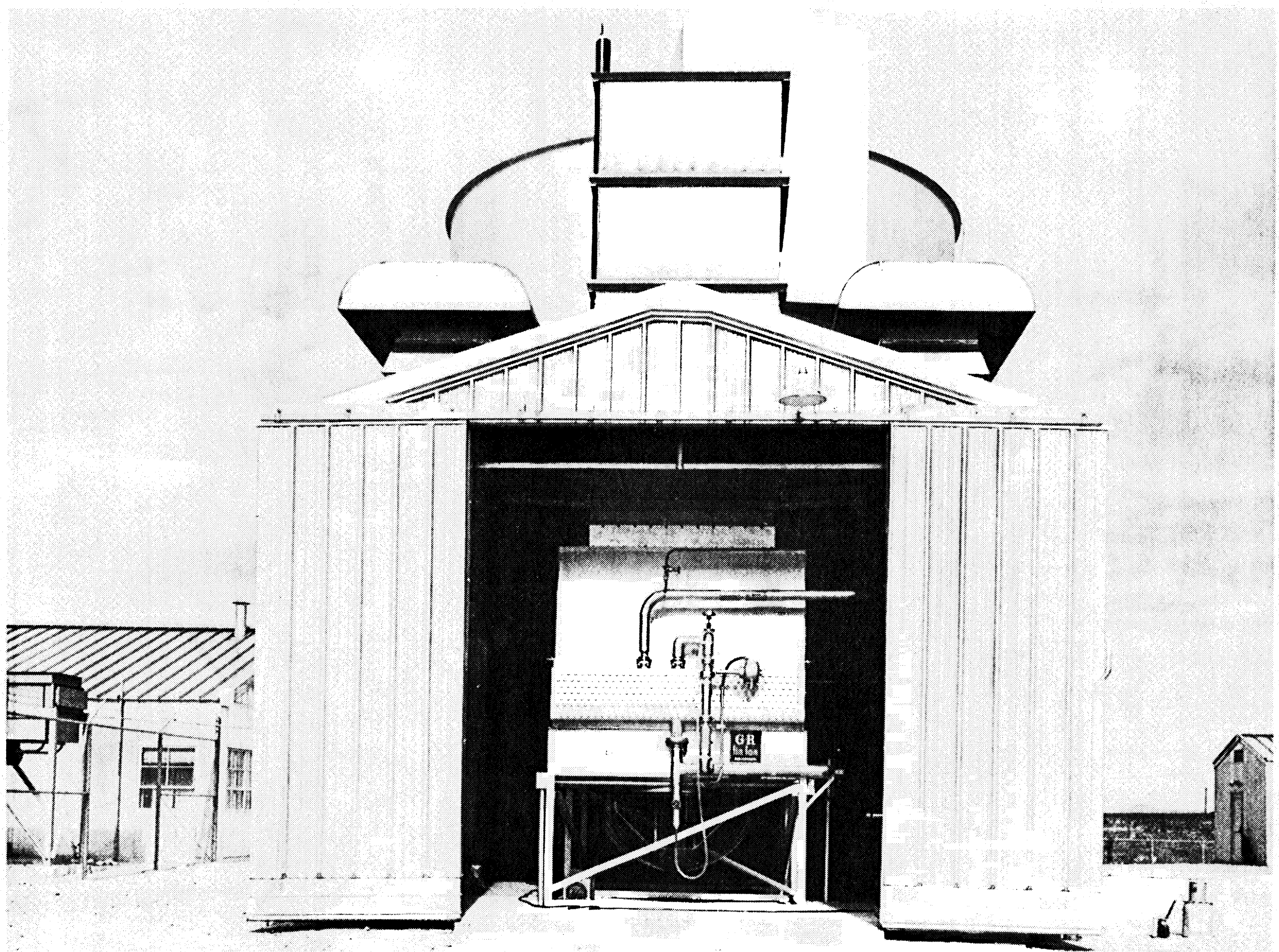
VIEW OF SL-1 OPERATING FLOOR TOWARD TURBINE-GENERATOR

FIGURE I-2



VIEW OF SL-1 OPERATING FLOOR TOWARD FEEDWATER PUMPING STATION

FIGURE I-3



P L CONDENSER INSTALLATION

FIGURE I-4

steel support grid, which is bolted to the core support pads attached to the thermal shield. Sheet aluminum shrouding is riveted to the core stanchions to form both control rod scabbards and envelopes to contain fuel assemblies. The control rod scabbards extend about 26 inches above the core to form a shroud around the rods when they are raised. There are five cruciform control rod scabbards and four tee scabbards.

The structure provides a total of sixteen envelopes to contain fuel assemblies. The four corner envelopes hold three fuel assemblies each and the remaining twelve hold four fuel assemblies each. The maximum core capacity is fifty-nine fuel assemblies and one source assembly.

The SL-1 core loading consisted of only 40 fuel assemblies arranged to approximate a right circular cylinder and 20 dummy assemblies, one of which contains an Sb-Be neutron source. This arrangement of the core is as it existed just prior to the incident (Figure I - 7). The active core is 25.8 inches high with an equivalent diameter of 31.4 inches and an over-all water to metal ratio of 2 to 1.

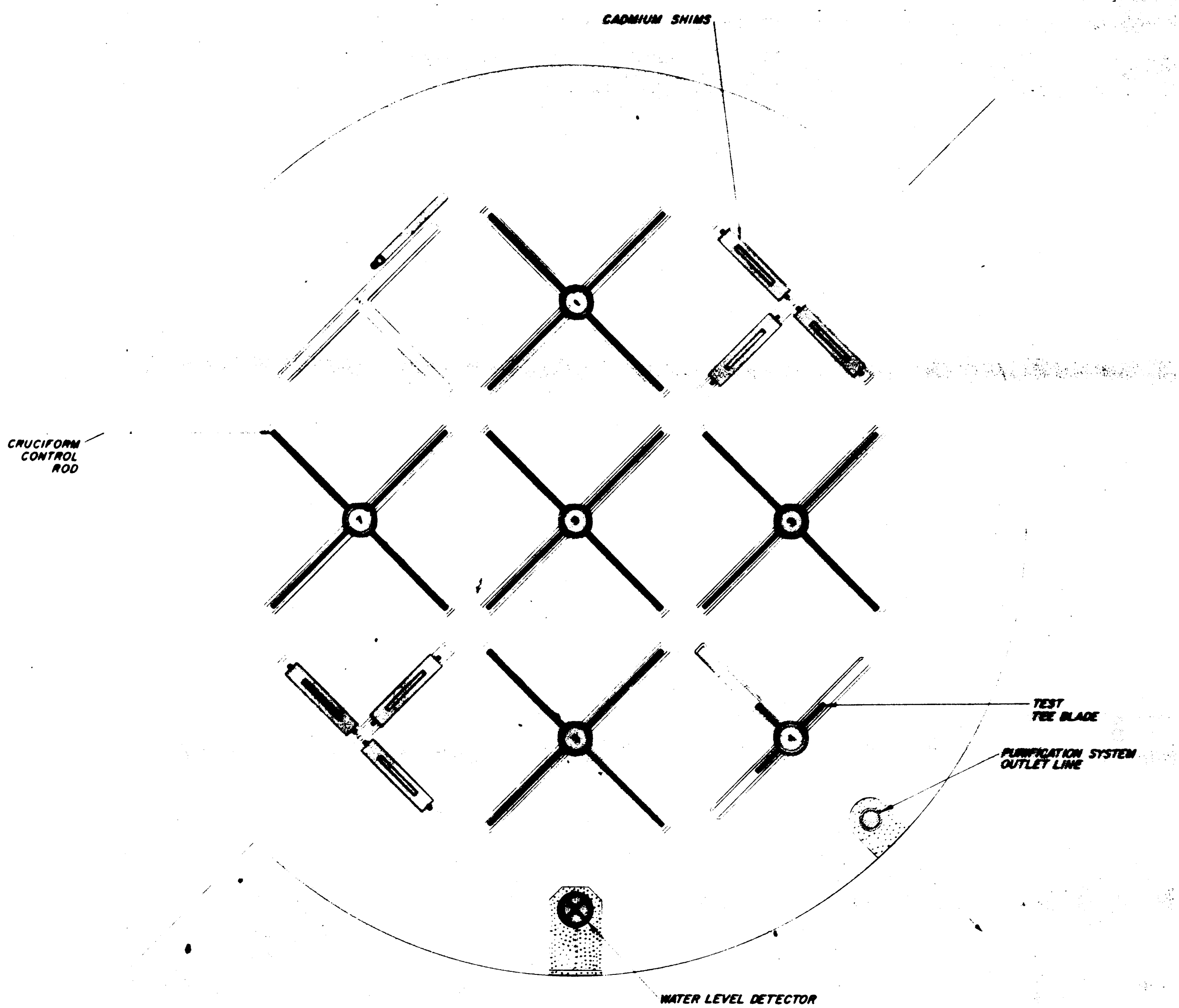
The fuel assemblies consist of nine 0.120 inch thick fuel plates assembled to two side plates by spot welding to form a box 3-7/8 inch square (Fig. I-8). A fuel plate consists of a 0.050 inch thick by 3.5 inch wide and 25.8 inch long center portion of aluminum-nickel-uranium alloy in a picture frame of X-8001 aluminum alloy and side clad of .035 inch thick X-8001 aluminum.

Each fuel assembly has a full length burnable poison strip of aluminum alloy containing boron which is spot welded to one side plate. The strip is 25.8 inches long by 3.875 inches wide by a nominal 0.026 inch thick, and contains 0.5 grams of B^{10}. In addition, the sixteen center fuel assemblies have a half-length strip welded to the lower half of the opposite side plate. This strip is nominally 0.021 inch thick and contains 0.2 grams of B^{10}.

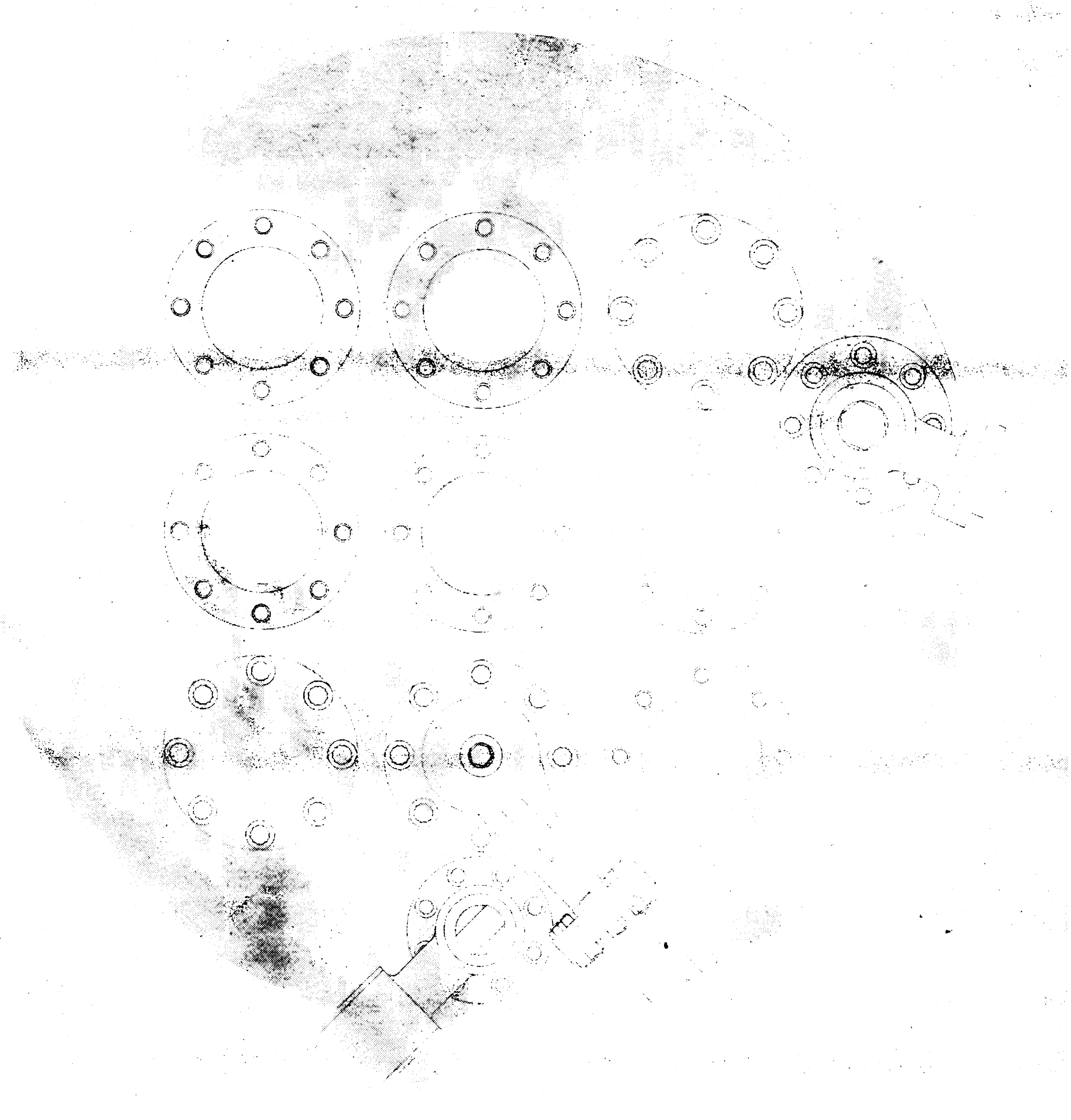
The fuel assembly spacing is maintained by Inconel springs which are fastened on each of the four sides at the top of the assembly. Fuel handling is accomplished by a gripper mechanism which attaches to a stainless steel gripper tip threaded and pinned into the upper end of the fuel assembly.

A holddown device rests on top of each group of four assemblies. It consists of a 7-7/8 inch square box, 3 inches high, fabricated of X-8001 aluminum alloy.

The 40 fuel assembly core utilizes five cruciform control rods composed of cadmium sheets with X-8001 aluminum alloy cladding. The cadmium portion of the cruciform is 14 inches by 14 inches by 0.060 inches thick and 34 inches long (Fig. I-9). The centrally located rod (No. 9) has a 17 inch bottom extension made of solid X-8001 aluminum alloy plate and the remaining rods have five inch extensions.



CONTROL RODS AND CADMIUM SHIMS



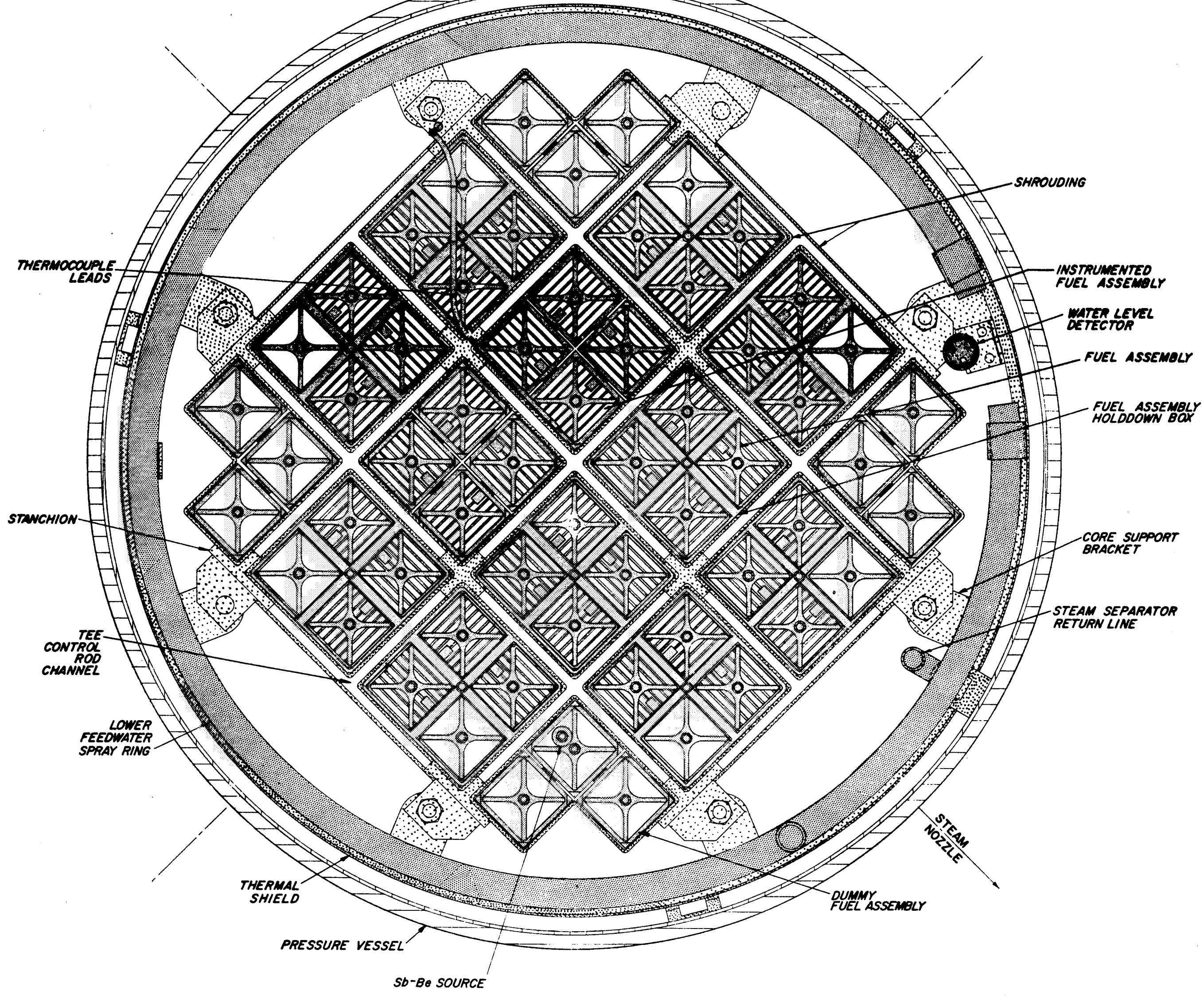
REACTOR VESSEL HEAD PHANTOM VIEW
WITH PORTS UNCOVERED BY EXCURSION
SHOWN OPEN

KEY:

- NON REMOVABLE CORE STRUCTURE

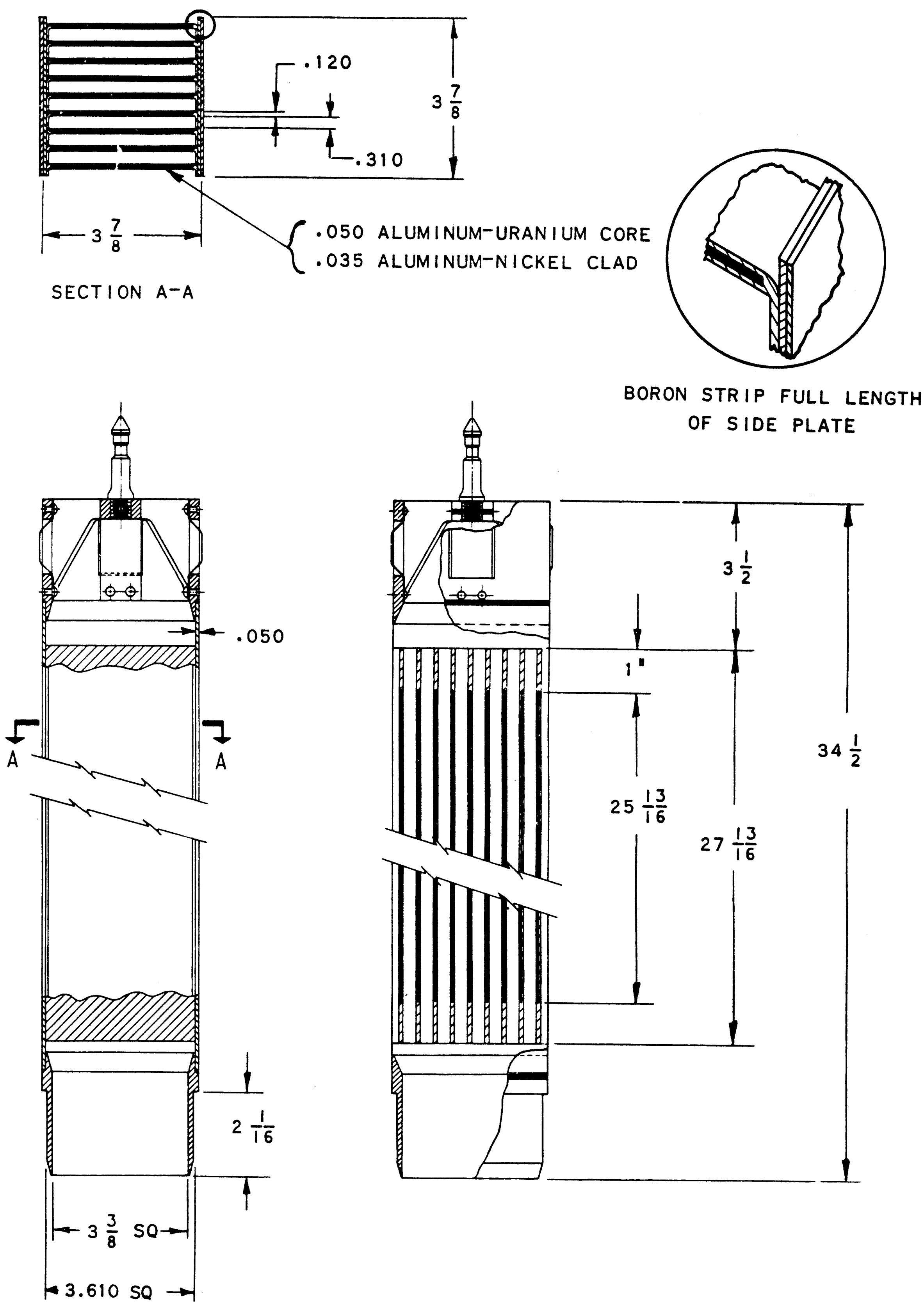
- LOWER SPRAY RING AND PIPING

- REMOVABLE CORE COMPONENTS AND INSTRUMENT



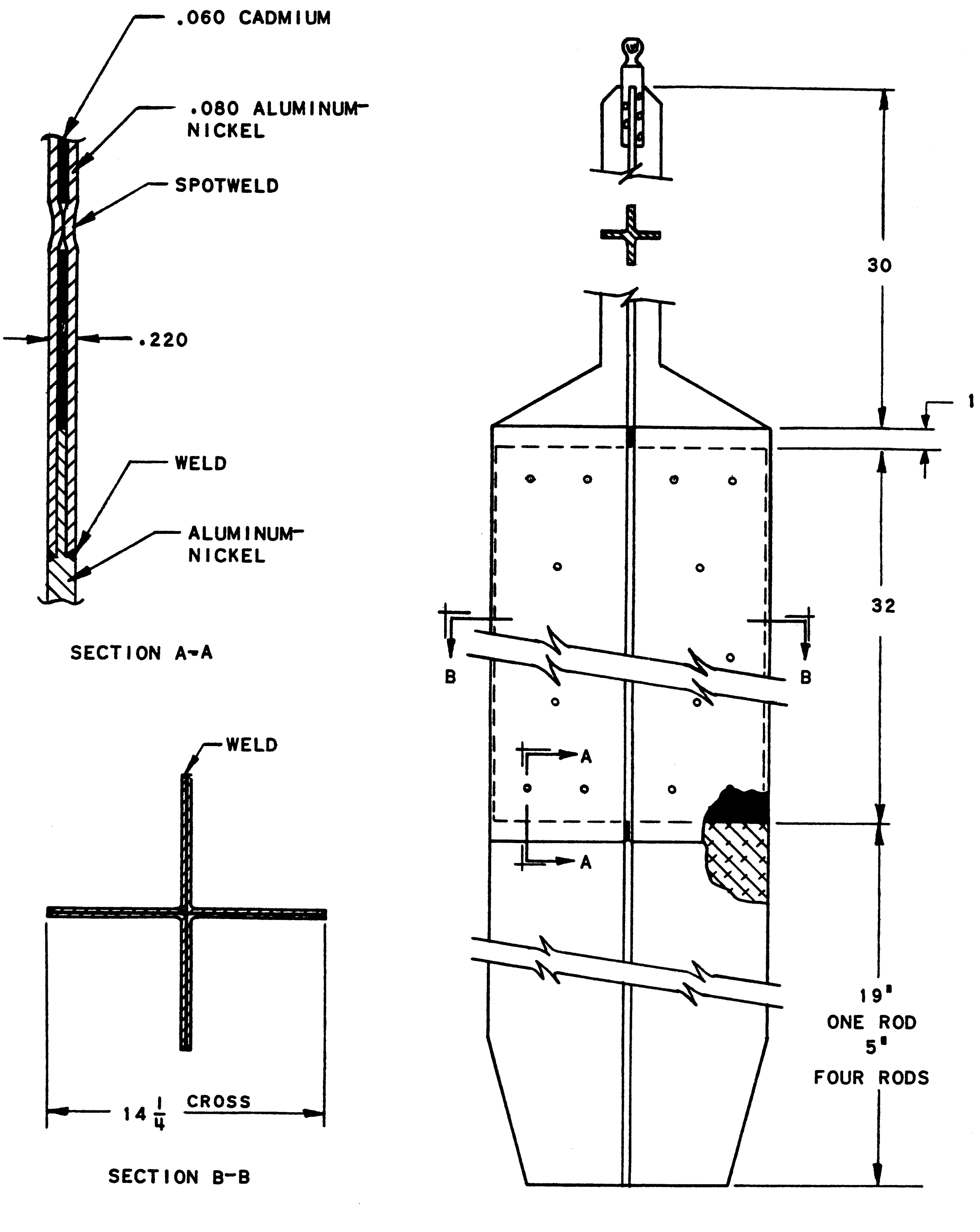
SL-1 CORE LOADING PLAN ON JANUARY 3, 1961

Fig. I-7



reprinted from ANL-5744 (Fig. 9)

SL-1 FUEL ASSEMBLY
Fig. I-8



reprinted from ANL-5744 (Fig. 10)

SL-1 CRUCIFORM CONTROL ROD

Fig. I-9

3. Reactor Vessel and Head

The SL-1 reactor pressure vessel is carbon steel (Type SA-212) clad with stainless steel (Type 304). The vessel consists of an ellipsoidal dished bottom head, a cylindrical center section with a top flange, and a flat upper head. Figure I-5 shows a view of the reactor pressure vessel. The internal diameter is 52-1/8 inches and the inside length is 14 feet, 6 inches. The vessel was designed for 400 psig pressure with a metal temperature of 500 ^{o}F.

The stainless steel clad upper head has nine flanged six inch diameter nozzles for control rod drives, one four inch diameter liquid level control opening, and one 2½ inch liquid level control opening. The overall height of this head assembly is 24 inches.

A cylinder of one quarter inch sheet steel is welded to the top of the head surrounding the nozzles to form a container for shielding material which consists of iron punchings, boric-oxide, and gravel.

4. Control Rod Drive Mechanism

The five cruciform control rods are actuated by rack and pinion drive mechanisms. Fig. I-10 shows the control rod drive mechanisms mounted on the vessel head nozzles.

5. Systems

a. Main Steam System (Figure I-11)

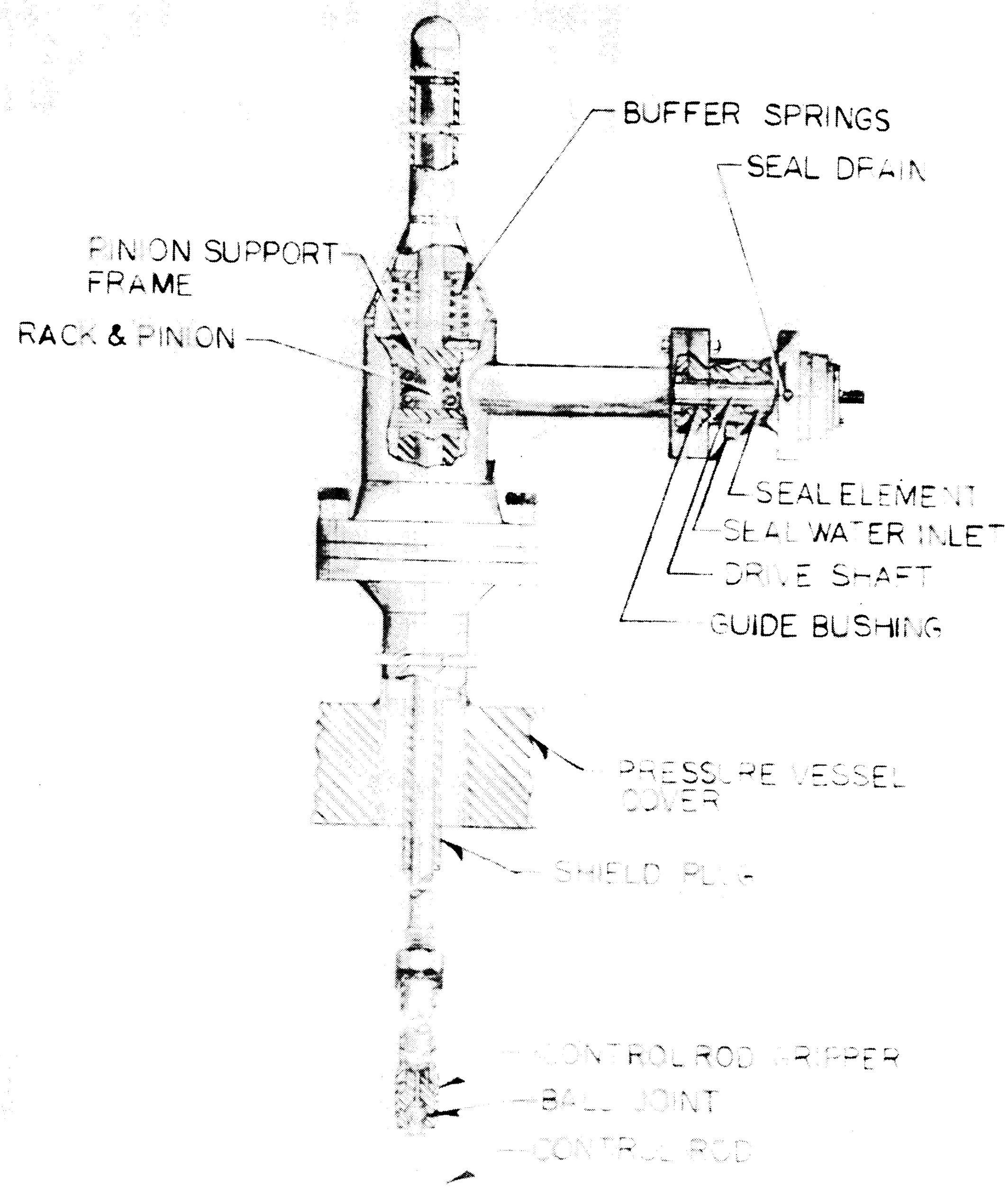
Steam from the reactor flows to the turbine. Excess steam produced by the reactor is automatically bypassed to the condenser through two automatic bypass valves. The bypass valves are capable of passing all of the turbine steam load in the event of a turbine trip. A second back pressure regulating valve serves to maintain a pressure of 40 psig in the space heat exchanger and downstream from the turbine pressure regulator.

b. Condensate System

Exhaust steam from the turnbine is condensed in an air-cooled finned tube-type condenser operating at five inches of mercury absolute pressure. Condenser cooling air is supplied at the proper temperature and flow rate to provide constant turbine back pressure. This is accomplished by controlled mixing of the recirculating and incoming air streams.

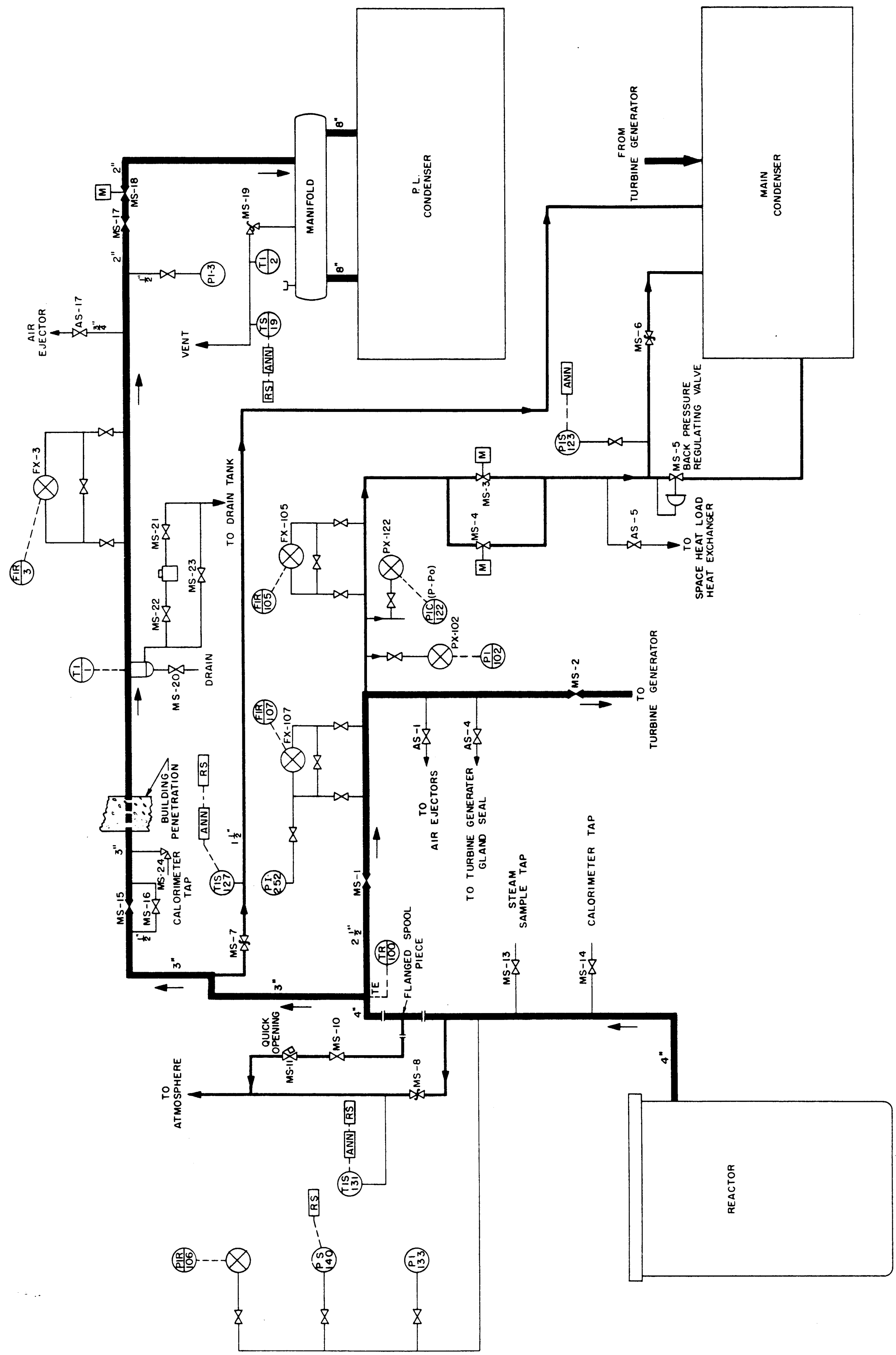
c. Feedwater System

Condensed steam from the condenser, air ejectors, and space heating system is collected in the hotwell tank. This water is returned to the reactor by one of two feedwater pumps. Condensate is also used as cooling



SL-1 CONTROL ROD DRIVE MECHANISM

FIGURE I-10



SL-1 MAIN STEAM SYSTEM

FIGURE I-11

water in the primary shield cooling heat exchangers and the air ejector after-condensers. A separate condensate circulating pump is used to supply these systems with water. Primary shield cooling is also provided by a natural circulation loop to an air-cooled finned tube-type heat exchanger.

Water level in the hotwell is maintained to provide adequate submergence of the feedwater pumps. Make-up water can be added manually from the demineralized water storage system. The returning feedwater serves as the coolant for the purification water cooler. In this cooler the 135 °F feedwater is heated to 175 °F by the heat supplied from the reactor water. The feedwater is passed through a filter and then enters the reactor through a spray ring located at the level of the top of the reactor core.

d. Primary Water Purification System

Reactor water is continuously re-circulated through a purification system. This system removed suspended and dissolved impurities in order to contrōl the build-up of radioactivity by deposition in the plant systems and turbine.

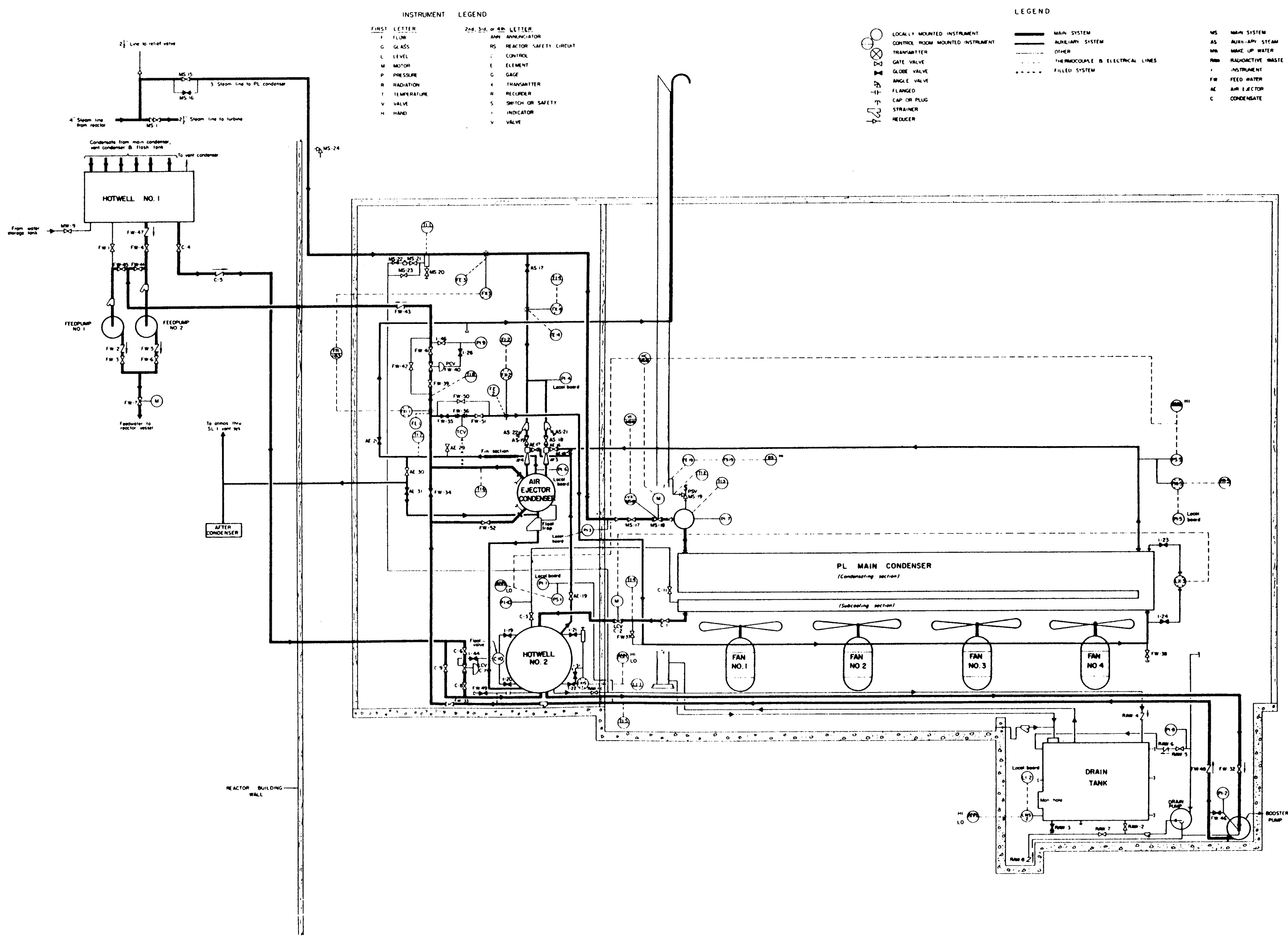
Water from the reactor is taken out near the bottom of the core and returned through the feedwater line. The water, coming from the reactor, first passes through a five gallon holdup tank to reduce the N^{16} activity. Then the water is cooled by regenerative heat exchange with the feedwater. After cooling, the water is pumped through a filter, a mixed bed demineralizer and returned to the feedwater line. Part of the flow bypasses the mixed bed demineralizer and flows to a cation demineralizer to maintain pH between 6.5 and 7.

e. Poison Injection System

A back-up shutdown system has been incorporated in the design of the SL-1 plant, which provides for the addition of boric acid to the reactor water. At the discretion of the operating personnel, a concentrated boric acid solution may be pumped into the reactor through the upper feedwater spray ring. The manually operated pump has a capacity of at least 25 gallons per hour when the reactor is at operating pressure. With the vessel at atmospheric pressure, the solution can be introduced through the upper feedwater spray ring by gravity feed through a by-pass hose.

f. Plant Expansion Facility

The purpose of the plant expansion facility (designed and installed by Combustion Engineering, Inc.) is to provide additional heat dump capacity for higher power operation of the original SL-1 plant (Figure I-12). This system will handle an additional 13,000 pounds per hour steam flow, thus providing capacity for reactor operation at a power level up to 8 MW (t). It consists mainly of a PL-2 type air-cooled condenser, hotwell, air ejectors, return booster pump, and required instrumentation and controls.



PL CONDENSER LOOP FLOW DIAGRAM

FIGURE I-12

6. Instrumentation and Controls

a. Nuclear Instrumentation

The nuclear instrumentation system is composed of startup instrumentation, containing source range and intermediate range equipment, and power range equipment utilized during power operation to monitor reactor neutron flux level and provide over-power protection (Figure I-13).

The SL-1 installation uses two boron trifluoride counters with scaler readout for the source range channels to provide indication only with no automatic proctor protection.

Two compensated ion chamber channels are utilized during start-up in the intermediate range. One channel provides linear readout (indicating and recording) with automatic period protection for the reactor. The other provides log power readout (indicating and recording). These two channels will operate over the intermediate flux range and the power range.

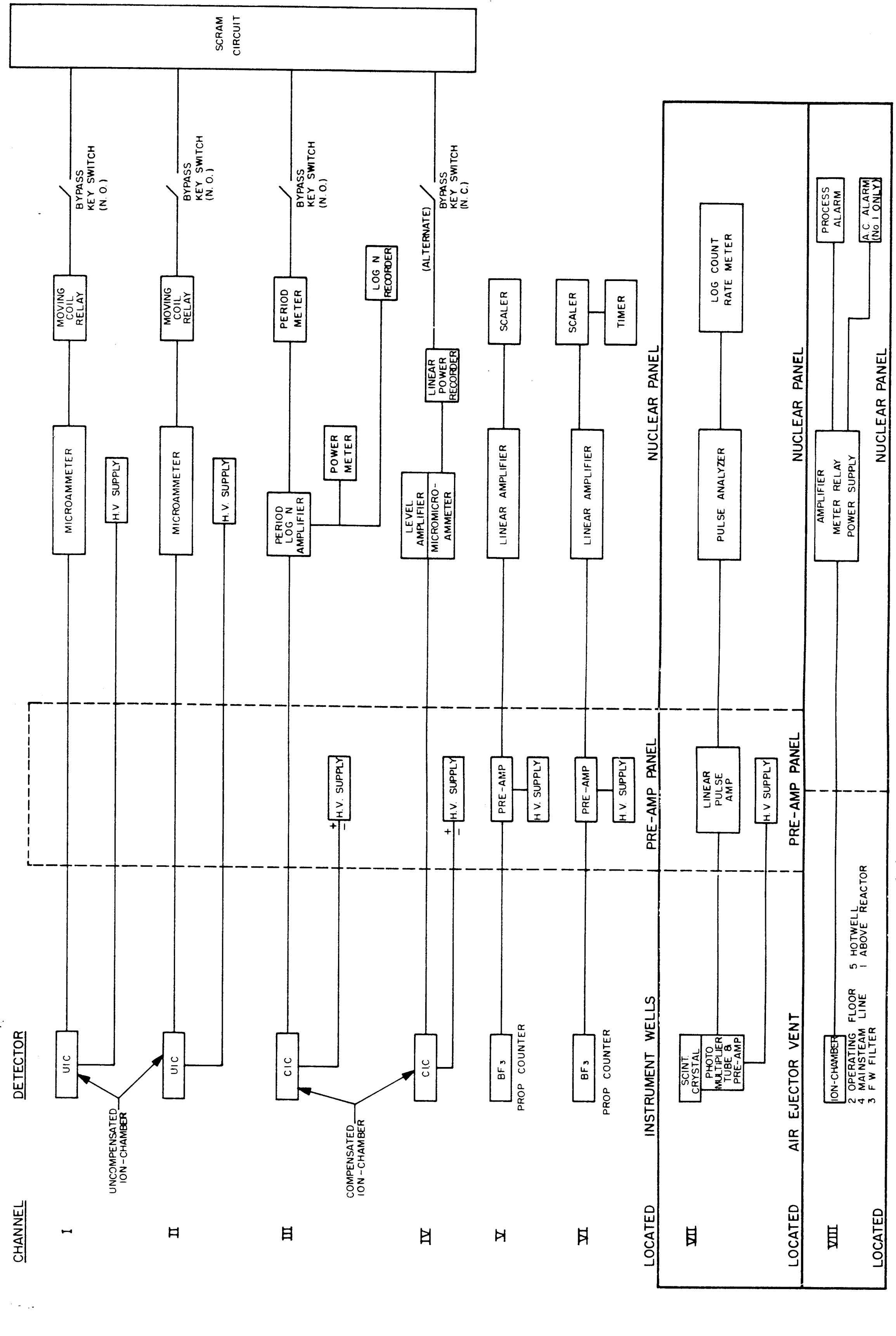
Signals for reactor over-power protection are generated from two uncompensated ion chamber channels. Meter relay trip circuits and indicated neutron flux readout is available at the control panel for these power range channels.

b. Process Instrumentation

Process instrumentation signals are used for indicating or recording the plant parameters. Feedwater flow, reactor steam pressure, main steam flow, by-pass steam flow, condenser vacuum, condenser air in and out temperature, feedwater temperature, and reactor water level are recorded on the main process panel. Feedwater pressure, main steam pressure, hot-well level, main steam pressure, $P-P_o$, system temperatures (48 points) and conductivity are indicated.

c. Reactor Control System

The steam void coefficient of reactivity acts on the reactor to move the reactor power in a direction opposite to that required to follow a load change. The SL-1 reactor control system accommodates load changes by adjusting the reactor thermal output to the level of the load or by by-passing steam to keep the output of the reactor constant during load changes. A pressure signal (P) from the main steam line is fed to the pressure deviation recorder where it is compared with pressure reference setting (P_o). From the pressure deviation recorder a signal proportional to $P-P_o$ is re-transmitted by means of a slide wire to a position controller. For the first control mode the controller drives the center control rod to increase or decrease reactor power as required. For the second control mode the controller operates a valve in the steam by-pass line around the turbine which compensates for the change in steam demand of the turbine.



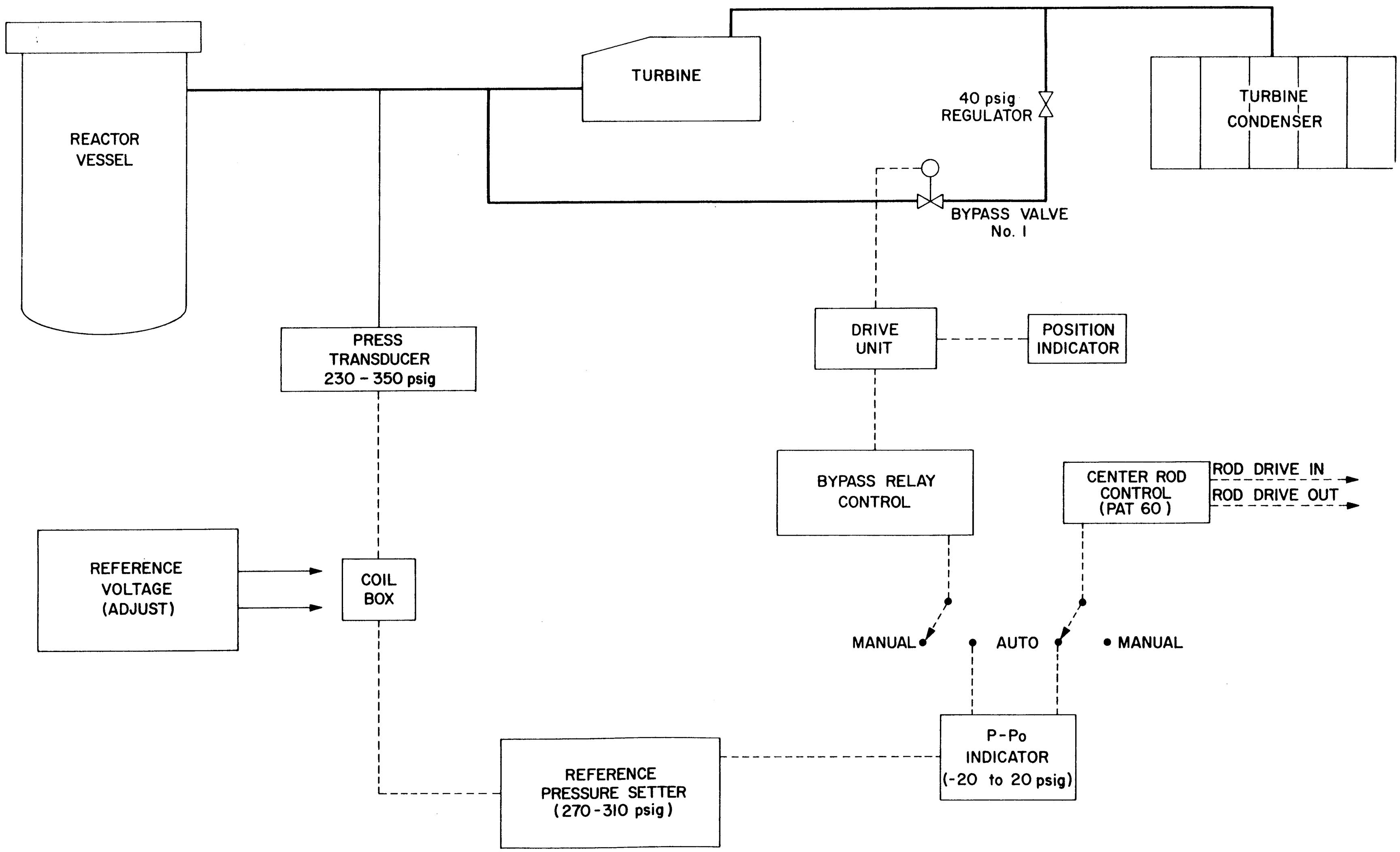
NUCLEAR CHANNEL BLOCK DIAGRAM

FIGURE I-13

d. Reactor Water Level Control (Figure I-14)

There are two displacement float liquid level sensor transmitters in the reactor. The signal from the first is used for recording liquid level, controlling the feedwater regulating valve and for high and low level alarms. The signal from the second is used to give a high and low liquid level scram.

Since the steam flow from the reactor will vary with time, it is necessary to control the flow of feedwater to the reactor to maintain the reactor water level within the desired limits. Either of two methods is available for controlling the feedwater regulating valve in the feedwater line. For the first method, three-point control signals from the steam flow, reactor water level, reactor water level and the feedwater flow, are combined and fed into the controller which acuates the flow regulating valve. In this controller the reactor water level signal is over-riding. For the second method, single point control, the reactor water level signal alone is fed to the controller.



REACTOR PRESSURE AND DEMAND CONTROL BLOCK DIAGRAM

FIGURE I-14

B. DESCRIPTION OF SL-1 INCIDENT AND PERSONNEL RECOVERY(6)

"First indication of trouble at the SL-1 (Stationary Low Power No. 1) reactor was an automatic alarm received at Atomic Energy Commission Fire Stations and Security Headquarters at 9:01 p.m. (MST) January 3, 1961. The alarm was immediately broadcast over all NRTS radio networks. At the same time, the personnel radiation monitor at the Gas Cooled Reactor Experiment gate house, about one mile distant, alarmed and remained erratic for several minutes.

"Upon the receipt of the alarm, which could have resulted from either excessive temperature or a pressure surge in the region above the reactor floor, the Central Facilities AEC Fire Department and AEC Security Forces responded. A Phillips Petroleum Company (operating contractor for some NRTS facilities) health physicist from the Materials Testing Reactor area was called at this time.

"The fire engines and security forces arrived at the SL-1 site, about eight miles from the central facilities area, at approximately 9:10 p.m. Security patrolmen opened the gates in the site area fence and later the south door of the SL-1 administration building. Firemen equipped with Scott Air Paks and radiation survey meters went through the administration building and the support facilities building in search of the operators and evidence of fire.

"The initial penetration went as far as the entrance to the reactor building; however, unusually high radiation levels there caused the search party to withdraw pending health physics guidance. No fire or smoke nor any personnel were seen in the support facilities or administration building. The searchers did not enter the reactor building proper.

"At 9:17 p.m. the Phillips health physicist arrived at the SL-1. He and a fireman, wearing Scott Air Paks, made another trip through the administration and support facilities buildings and as far as the foot of the stairs to the operating floor of the reactor building, where they encountered a radiation level of 25 roentgens per hour, the limit of the survey meter they were using. They retreated from the reactor building and thoroughly searched the administration and support facilities buildings looking for the three men believed to be on duty. They saw no one, nor any smoke or fire. During this search they encountered radiation fields of from 500 mr per hour to 10 r per hour.

"By this time a radio check to other NRTS installations confirmed that the three SL-1 operators had not gone to any of them, so it was now presumed they must be in the reactor building.

"At 9:35 p.m. two more Phillips health physicists arrived, already in protective clothing. One of them, with two firemen and with a 500 r per hour range survey meter, went up the stairs of the reactor building until a 200 r per hour radiation field was encountered. This group withdrew from the building to plan a course of action based on radiation levels noted. Then, with AEC approval, the other Phillips health physicist and an AEC fireman went to the top of the stairs and took a brief look at the reactor floor. Observed radiation levels of the order of 500 r per hour forced their quick withdrawal. They saw some evidence of damage but no bodies.

"By 9:36 p.m. key personnel of AEC-Idaho Operations Office, Combustion Engineering, Inc. (operating contractor for SL-1), and Phillips Petroleum Company had been notified of the SL-1 accident. Following notification, many personnel who played key roles in the rescue efforts at SL-1 had to travel from Idaho Falls to the SL-1 site, a distance of 41 miles. At 10:25 p.m. IDO designation of a Class I Disaster was broadcast over the NRTS radio network.

"When four Combustion Engineering personnel, including the SL-1 Plant Health Physicist, arrived, they decided to enter the 500 r per hour field. The four Combustion Engineering men, having verified that the three military men on duty had not left the site, prepared to enter onto the reactor operating floor.

"At approximately 10:35 p.m. the Combustion Engineering supervisors for plant operations and health physics, wearing Scott Air Paks and carrying two 500 roentgen scale Jordan Radectors, entered the reactor operating floor for less than two minutes. They saw two men; one moving. They withdrew and returned with two more Combustion Engineering men and an AEC health physicist.

"Two of the group picked up the man who was alive and put him on a stretcher at the head of the stairs. The other three of the group observed that the second man was apparently dead. The group got the stretcher down the stairs and out the west door within three minutes of entry, and put the stretcher in a panel truck. The man was taken in the panel truck to meet the ambulance, transferred, and taken to the junction of Highway 20 and Fillmore Blvd., where the AEC doctor was met. When the doctor examined the casualty at 11:14 p.m. he pronounced him dead and the ambulance returned with the body to the SL-1 site pending a decision on the temporary disposition of the body.

"At about 10:38 p.m. another group, made up of two military and two Phillips personnel, entered onto the reactor floor briefly to locate the third man. They located him and determined that he was dead and did not attempt to remove him.

"The recovery group went to the GCRE for preliminary decontamination. Gamma exposures of the five-man group ranged from 23 to 27 roentgens.

As the groups were returning from the GCRE, they stopped long enough to permit one military man and one AEC health physicist to go through the support facilities building and close doors to lessen the chance of a fire starting and spreading in the disaster area; the two men did not enter the reactor building on this trip. When the two men returned to the rest of the group, it proceeded on to the decontamination trailer set up at Fillmore Blvd. and Route No. 20. From here the group split up with part going to the Central Facilities Dispensary and the rest going to the Chemical Processing Plant for further decontamination.

"Having concluded that the remaining two operators were dead, the AEC-IDO health physicist suspended rescue efforts and ordered all personnel back to the roadblock established on Fillmore Blvd. at Highway 20.

"After the ambulance had been returned to SL-1 to await a decision on disposition of the body, personnel involved in the transfer of the body from the panel truck to the ambulance went to the Central Facilities Dispensary for decontamination. Between midnight and 3 a.m. on January 4 approximately 30 people who had been engaged in the emergency at the SL-1 area were admitted to the dispensary for secondary decontamination. These personnel included firemen, security patrolmen, and military personnel. Preliminary badge readings and urine sample analyses for these 30 people were received around 3:30 a.m. and indicated that all personnel could be released. To assist in the above-mentioned decontamination processes, four Phillips Petroleum Company health physicists came to the dispensary from the MTR and Engineering Test Reactor.

"At approximately 6 a.m. on the morning of January 4, a team of five men removed the body from the ambulance located in the SL-1 area. The body was disrobed in order to remove as much contamination as possible at the site. The body was replaced in the ambulance, covered with lead aprons for shielding purposes, and transported to the Chemical Processing Plant where surface decontamination was attempted.

"Individuals involved in the disrobing and transfer process received a maximum exposure of 770 millirems gamma. Prior to decontamination the reading from the first body was approximately 400 r per hour at the head region, approximately 100 r per hour at the feet, and from 200 to 300 r per hour over the remainder of the body. First efforts to decontaminate the body resulted in no significant decrease in the readings.

"Between 7 a.m. and 11 p.m. on January 4, the day following the incident, several entries into the reactor buildings were made. As a result of the entries, the second body was recovered, leaving one fatality to be recovered. Detailed events involved with removal of the second body are presented in a subsequent paragraph. A Hurst criticality dosimeter was recovered from just outside the door leading onto the reactor operating floor. Personnel history files were recovered from the Administrative Support Building. In addition, the reactor operating log book and all but one of the plant instrument charts were recovered from the Control

Room area. The instrument charts recovered are the following:

Condenser Air Temperature Inlet	Purification Water Temperature
Condenser Air Temperature Outlet	Reactor Pressure
By-Pass Steam Flow	Linear Power Level
Main Steam Flow	Log Power Level
Reactor Water Level	Feedwater Flow

"The linear power level and feedwater flow instruments are known to have been off at the time the charts were removed. The only chart not recovered was the Constant Air Monitor.

"During this same period investigation teams were organized by the AEC, Argonne National Laboratory, and Combustion Engineering, Inc. Efforts continued on planning removal of the last victim, and assessing the damage incurred.

"In addition to the normal continuous radiation monitoring stations which were operating at the time of the accident, radiological monitoring teams started intensive surveys of the adjacent areas and NRTS environs to evaluate any possible radiological hazard. These surveys are continuing. No radiological hazard to the public has been indicated.

"At approximately 4 p.m., January 4, 1961, preparations began to recover the second body from the reactor operating floor. The body was located in an area where radiation levels were estimated to be approximately 750 r per hour.

"A recovery team consisting of six military personnel and two AEC health physicists proceeded from the decontamination check point on Fillmore Blvd. near U. S. Highway 20, after having been extensively briefed, rehearsed, and attired in protective clothing, to the entrance of the SL-1 compound at about 7:30 p.m. Of this group, two military men and the two health physicists entered the Support Facilities Building through the side entrance into the maintenance workshop area. A blanket was placed on the floor in the control room.

"Because of the high radiation levels to be encountered, the maximum permissible working time on the reactor operating floor was limited to one minute. One health physicist was assigned to hold a stop watch and time the actual entrance to the reactor operating floor, signaling the two-man recovery team when their time was up. The other health physicist remained in the support facilities building to check the body for radiation after its removal from the reactor building.

"Having been briefed as to the location of the body to be recovered, the two-man team entered the reactor operating floor and proceeded directly to the body. One man picked up the victim's legs while the other grasped the body around the shoulders and they moved rapidly out of the high radiation area and down the stairway. Their one minute limit in the reactor area did not expire until they were part way down the stairway. The two men continued down the stairs and placed the body on the blanket in the control room.

"The second two-man team entered the Support Facility Building and went to the control room where they picked up the body by the four corners of the blanket and carried it out of the SL-1 compound. The work clothing or coveralls was removed from the body, which was then placed in an ambulance standing by for the purpose at 8:08 p.m. The ambulance proceeded with the body to the Chemical Processing Plant where facilities had been prepared to receive it. The third two man military team proceeded into the Support Facilities Building and on to the reactor operating floor for the purpose of attempting to gain some more information about the status of the remaining body and the reactor.

"The short periods of time that these recovery teams were in the high radiation areas on the reactor operating floor resulted in gamma exposures of from 1 rem (roentgen equivalent man) to about 13 rems.

"On Thursday evening, January 5, an official photographer entered the radioactive reactor compartment to photograph the scene of the explosion. Radiation fields greater than 500 r per hour were reported by the accompanying health physicist. The photographer, wearing protective clothing and breathing apparatus, was allowed 30 seconds to complete his assignment. By entering the reactor compartment only long enough to trigger his camera and withdrawing to a less radioactive area to change film and make adjustments, the photographer was able to obtain the interior photograph needed. This photograph assisted AEC investigating teams in making plans to recover the third body and evaluating damage to the reactor operating floor area. Maximum radiation exposure of these two men was less than two roentgens gamma of radiation.

"The plan for removal of this third body was to position a large net (5' x 20') under it and attempt to lower the body onto the net. The net itself was fastened to the end of a crane boom. The large doors on the reactor building that are used for moving equipment in and out of the building were opened to permit the crane to position the net just below the body. A closed circuit television camera had been placed in the reactor building to help position the net.

"When the net was in position, teams of two men each were to move in quickly and try to lower the body onto the net. Because of radiation fields, each team had less than a minute to make their attempt at freeing the body.

"Due to malfunction of the television equipment, it was necessary to use the first team of men to check that the net was properly positioned; they accomplished their mission in less than their allotted time.

"Four additional teams were used to accomplish the mission of freeing the body and lowering it onto the net. A sixth crew, outside the building was used to move the crane which held the net. The third body was removed from the building at 2:37 a.m. on January 9, 1961. The estimated doses received by the men entering the reactor building to free the body ranged from 2.5 to 7.5 rem.

"Recovery operations were completed at 4:42 a.m. January 9, 1961.

"Official photographers have made a permanent record of activities at the SL-1 area. Aerial photographs were taken late Friday, January 6, 1961, to record the condition of the reactor building exterior, which appears undamaged.

"At 1:45 a.m. Sunday, January 8, 1961, a photographer, accompanied by a health physicist, photographed the reactor compartment. The photograph was requested by the Technical Advisory Committee which is assisting the Idaho Operations Office in planning the recovery of the third victim. A photograph of the control room was also taken. Readings of the high range gamma dosimeters worn by the men showed a maximum exposure of less than three roentgens.

"Entry to the reactor building continued to be a hazardous undertaking. To protect individuals from contamination, a detailed procedure is observed prior to entry. A detailed plan of action for each operation is established in order to obtain maximum benefit from the limited observation time of one to two minutes. AEC and Combustion Engineering health physicists personnel control the disaster field operations to ensure maximum safety for all participants. They determine who may enter, the radiation exposures to be tolerated and the equipment to be utilized.

"The person assigned an entry mission and a health physicist are each dressed in two pairs of coveralls, shoe covers, and gloves. Around the wrists and ankles, tape is used to ensure no skin remains exposed. Caps and respiratory protection equipment plus miscellaneous radiation detection equipment complete the outfitting of participants. Following exit from the contaminated area, clothing is removed and participants are decontaminated, if necessary, by scrubbing with soap and water.

"Since radiation effects are cumulative, each entry by an individual brings him closer to prescribed maximum permissible limits. Exposures to personnel are kept as low as possible by strict limitations and careful planning. To prevent multiple high exposures to individuals the missions are assigned to different personnel, thereby requiring a larger number of persons.

"There have been 23 persons who have received radiation exposures during activities at the SL-1 site varying from three roentgens to

27 roentgens total body exposure. Of the total, 14 received exposures of three to twelve roentgens, six were in the 12 to 25 r range, and three above the 25 r. Precautionary medical checkups did not disclose any clinical symptoms."

C. ESTABLISHMENT OF RECOVERY ORGANIZATION

1. Organization

As a result of the SL-1 incident on January 3, 1961, a reorganization and augmentation of the Combustion staff at the National Reactor Testing Station was required. In addition, substantial support from the Nuclear Division staff in Windsor was required. (See Organizational Chart, Figure I-15)

The pre-incident SL-1 scope covered supervision of operations, testing, and training of military personnel. The post incident SL-1 recovery operations scope included planning and equipment design for the recovery effort, operations, and health physics control of the SL-1 Site and emergency Control Point. Four functional sections were established under a Site Manager. The scope of each is presented below:

a. Planning and Design

(1) Develops a master plan for plant decontamination and core removal

(2) Designs and/or procures equipment

(3) Prepares general procedures

(4) Plans and builds mock-ups, coordinates tests, and establishes training requirements

(5) Coordinate preparation of progress and completion reports

(6) Plans and provides direction for SL-1 core metallurgical examination at NRTS Hot Cell

b. Operations

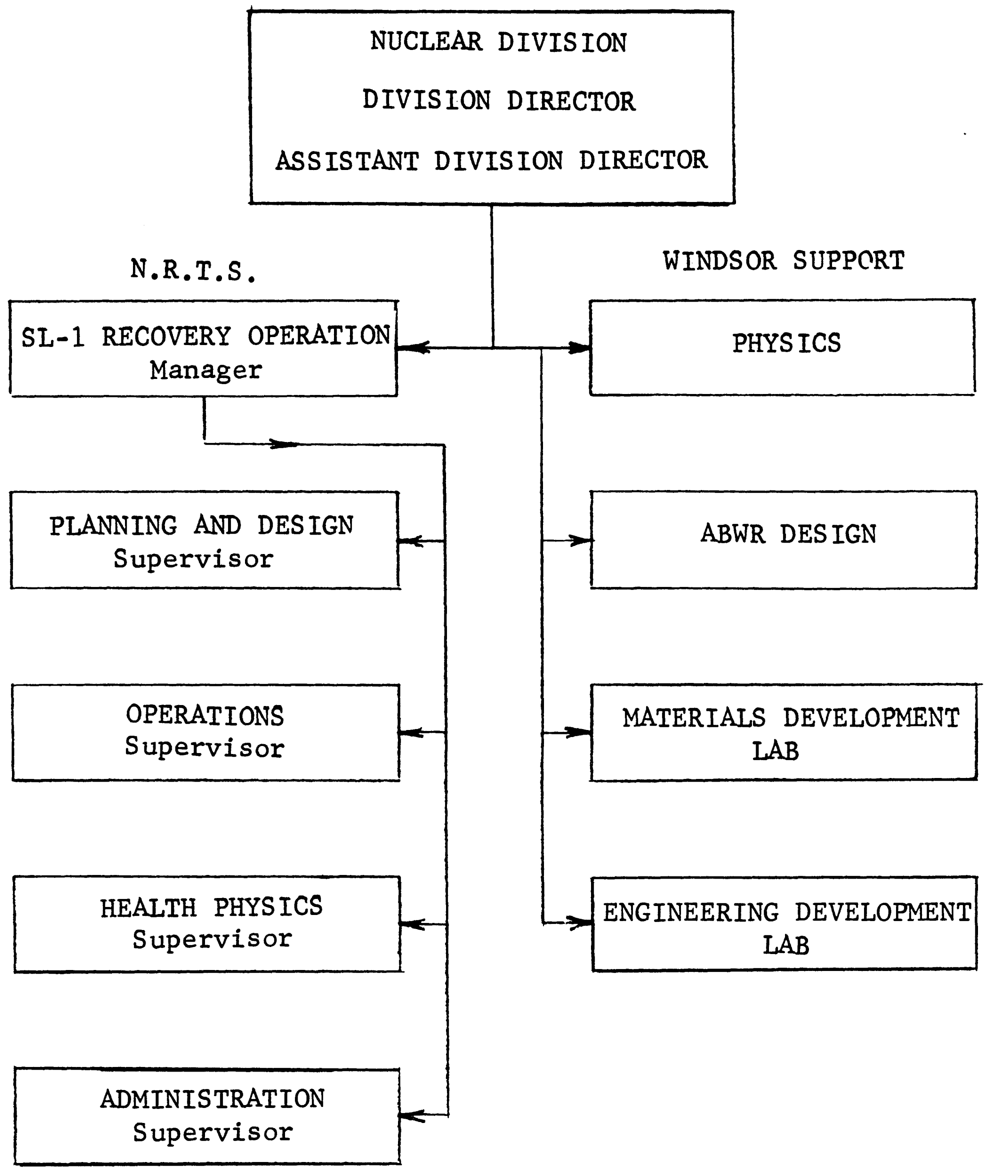
(1) Coordinates and/or performs recovery operations in plant

(2) Prepares detailed procedures for recovery operation

(3) Maintains equipment

(4) Establishes requirements and schedules availability of manpower for decontamination and core removal

(5) Provide operator trainees for mock-up testing



COMBUSTION ENGINEERING ORGANIZATION
FOR SL-1 RECOVERY OPERATION

FIGURE I-15

c. Health Physics

(1) Operates health physics Control Point

(2) Control exposure levels of personnel and maintains records of personnel exposure

(3) Monitors all operations with SL-1 Site

(4) Conducts radiation surveys of SL-1 Site

(5) Prepares reports of radiation surveys and personnel exposures

d. Administration

Supervises SL-1 Site administrative activities including budget control, operational costing, personnel administration, security and classification, material procurement and inventory control, administrative services, and records control.

2. Planning and Design Task

The development of a plan for plant deactivation, plant decontamination, and core removal was assigned to a planning and design section. The effort of this section was organized into several tasks.

Task 1 - Plant Deactivation

Scope includes developing methods and equipment needed to establish reactivity condition of SL-1 core and to add a poison solution to the reactor vessel.

Task 2 - Radiation Survey and Instrumentation

Scope covers planning and providing neutron and gamma monitors and instrumentation to locate and measure radiation sources in reactor building.

Task 3 - Remote Decontamination

Scope includes development of methods for removal of high radiation sources (excluding vessel head and core) remotely from reactor building.

Task 4 - Low Level Decontamination

Scope covers development of methods for low level direct decontamination of SL-1, buildings and yard, and waste disposal.

Task 5 - Core Removal

Scope includes development of methods and equipment for reactor vessel head, internals, and core removal.

Task 6 - Core Metallurgical Examination

Scope covers planning and directing the metallurgical examination of the SL-1 core.

3. Facilities

a. Office

Six days after the incident, Combustion established offices in the NRTS Central Facilities area for the technical staff and for the handling of procurement, personnel, security, communication, records, and other administrative functions to support the recovery operation. Procedures were modified to meet the emergency nature of the requirements of the technical staff, with full regard for subsequent review by the Commission. Thirty-five people were ultimately housed in two of the bungalows made available to Combustion by the Commission. This included 28 Combustion personnel and seven persons from supporting organizations. Because of the broad interest within the Commission on every aspect of the recovery operation and the concurrent efforts by many groups within Combustion, every task was formalized in a report and distributed to key persons both within the Commission and Combustion.

On the day following the incident, a systematic program of record recovery was established. First priority was given to the recovery of records such as operational and maintenance logs which might divulge information pertinent to a full analysis of the incident. After these records were retrieved from SL-1, copies were made of the records and the originals turned over to the Commission for their permanent storage. In subsequent entries into the plant all records and files were brought out.

b. Control Point

The Idaho Operations Office, operating within the scope of the IDO Disaster Plan, assumed health physics control of the emergency recovery operation at SL-1 from January 3rd until January 15th. To restrict access to the SL-1 Site, a Control Point was established near the junction of Fillmore Boulevard and U. S. Highway 20, which was one mile from the Site. This Control Point served as a dressing and decontamination site as well as a check point. On January 15th, Combustion Engineering, Inc. re-assumed health physics control of recovery operations.

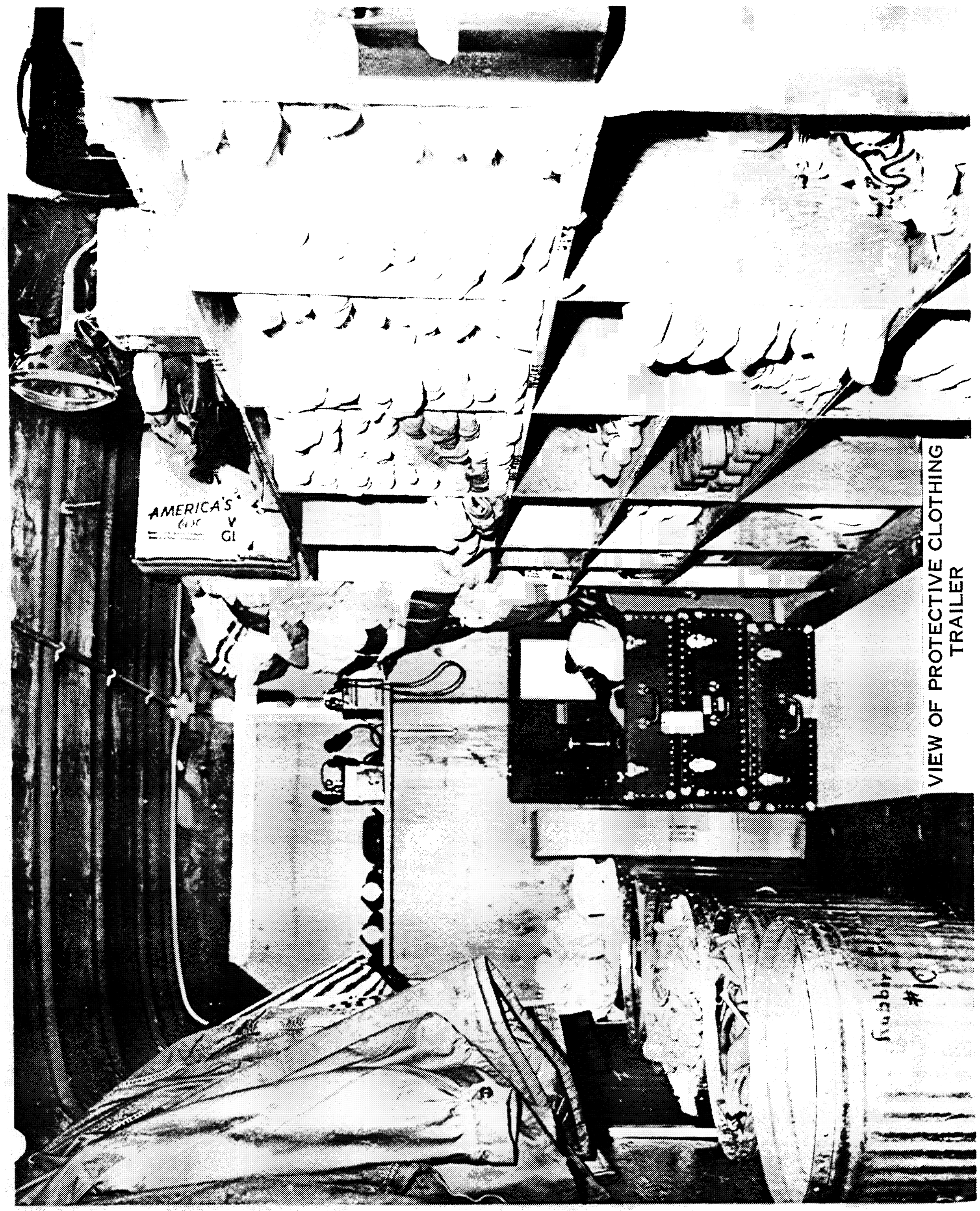
The Health and Safety group for Combustion Engineering, Inc., during the recovery operation, was comprised of health physics personnel from the Combustion Engineering Nuclear Division and military personnel from the SL-1 Cadre. The CEI Health and Safety group established their main headquarters at Central Facilities and maintained the Control Point on Fillmore Boulevard for access to the SL-1 Facilities.

Close liaison was established and maintained between CEI Health and Safety group and the IDO Site Survey group. Weekly meetings were scheduled to review Health and Safety aspects of the recovery operations. SL-1 Health Physics Data Reports were issued to the Idaho Operations Office. A total of twelve reports were made during the period of January 3 through May 20, 1961. These reports covered radiation surveys, results of air samples, soil samples, smear samples, personnel exposures, and essentially all aspects of Health and Safety activities concerned with the recovery operations.

Figure I-16 shows the physical layout of the Control Point and its relation to the SL-1 Site which appears in the background. No personnel were allowed to pass beyond its confines unless properly suited and accompanied by a Health Physics representative. A dressing trailer was provided where personnel were properly suited with protective clothing and required respiratory protection. Figure I-17 shows an inside view of this trailer. Before entering the controlled area, personnel were required to leave through a trailer serving as a Buffer Zone. Personnel entered the cold side of the trailer for final equipment inspection and issuance of personnel metering devices Figure I-18, consisting of one film badge and two dosimeters (low-range - 0 to 200 mr, and high range - 0 to 1000 mr). Upon returning from the Site, personnel entered the hot side of the Buffer Zone to remove their protective garments and equipment. Before leaving, personnel were monitored, and decontamination was performed when necessary. Two other house trailers served as administrative offices for Contractor personnel and the CEI Health Physics supervisor. An electronics maintenance shop was set up in yet another trailer. Instrument repairs and calibration checks were made in this trailer. Located at the front of the electronics shop was an observation and communication point for maintaining contact with personnel working in the SL-1 facility. The facilities described above made up the Control Point at the end of the SL-1 deactivation effort. The requirements for and experience with the Control Point dictated several modifications during the months following the incident.

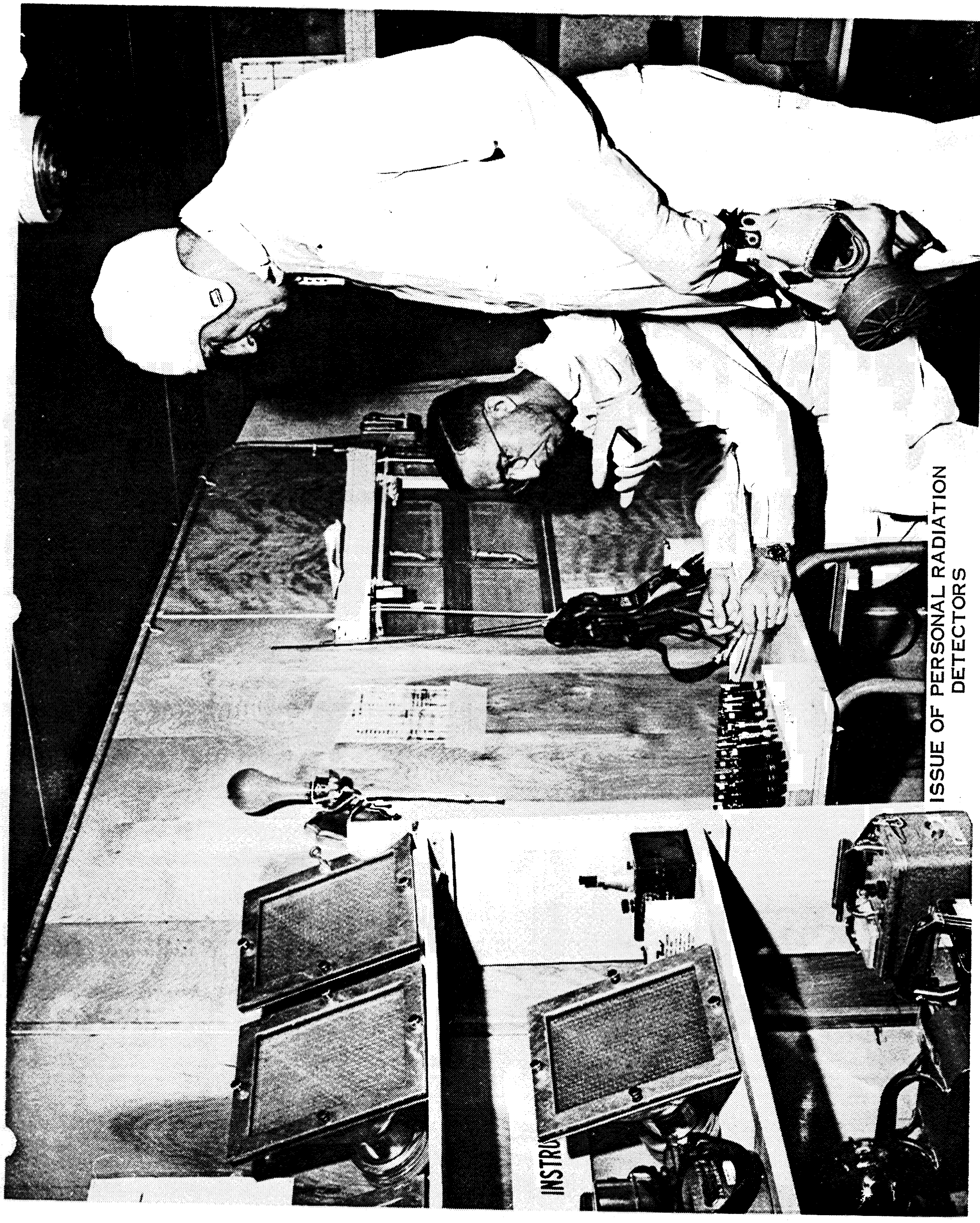
CONTROL POINT FOR SL-1
RECOVERY OPERATION

FIGURE I-16



VIEW OF PROTECTIVE CLOTHING TRAILER

FIGURE I-17



ISSUE OF PERSONAL RADIATION DETECTORS

FIGURE I-18

D. CONDITION OF SL-1 REACTOR IMMEDIATELY AFTER INCIDENT

1. Physical Condition

The physical condition of the SL-1 facility immediately following the incident on January 3, 1961 was evaluated by studying photographs taken of the operating floor and from testimony of personnel entering the reactor building. The conclusion was drawn early that the physical damage appeared to be confined to the reactor operating room. Six photographs made of the operating floor revealed that the area of damage was confined within the reactor vessel and to the vicinity above the reactor head (Figure I-19). Shield blocks which had been moved away from the reactor top head area appeared to be in good condition and in the same locations as before the incident. Control rod mechanism housings which were neatly lined up in front of the electrical switch gear panel were undisturbed and a single mechanism housing was still bolted to the reactor vessel head. All major control rod drive mechanism parts have been located with the exception of two shield plugs. The location of a tool necessary for the withdrawal of a control rod is also unknown. The water level indicator housing and blank nozzle shield plugs were still intact on the vessel head.

The vessel head shield cover plate had been blown upward locally from the impact of the blast. Steel punchings which served as the shielding material, was generally scattered around the reactor operating floor.

Two of the control rod drive shield plugs had partially penetrated the fan floor directly above the reactor. A third shield plug and connecting rod extension rested on top of the reactor head. Two control rod extensions were observed protruding through the vessel head nozzles.

The steel structure of the fan floor appeared to be bent as a result of blast damage. Holes in the steel sheeting which made up the fan floor were observed directly above the reactor head area.

Early observers at the SL-1 noted a steam cloud blowing out of the condenser cooling air exhaust. Observers of the operating floor noted the presence of water on the floor and at the bottom of the reactor stairs. Thus, it was apparent that an unknown amount of water had been ejected from the reactor.

All lights were still functioning in the operating room except one directly above the reactor head, which had been shattered by the blast.

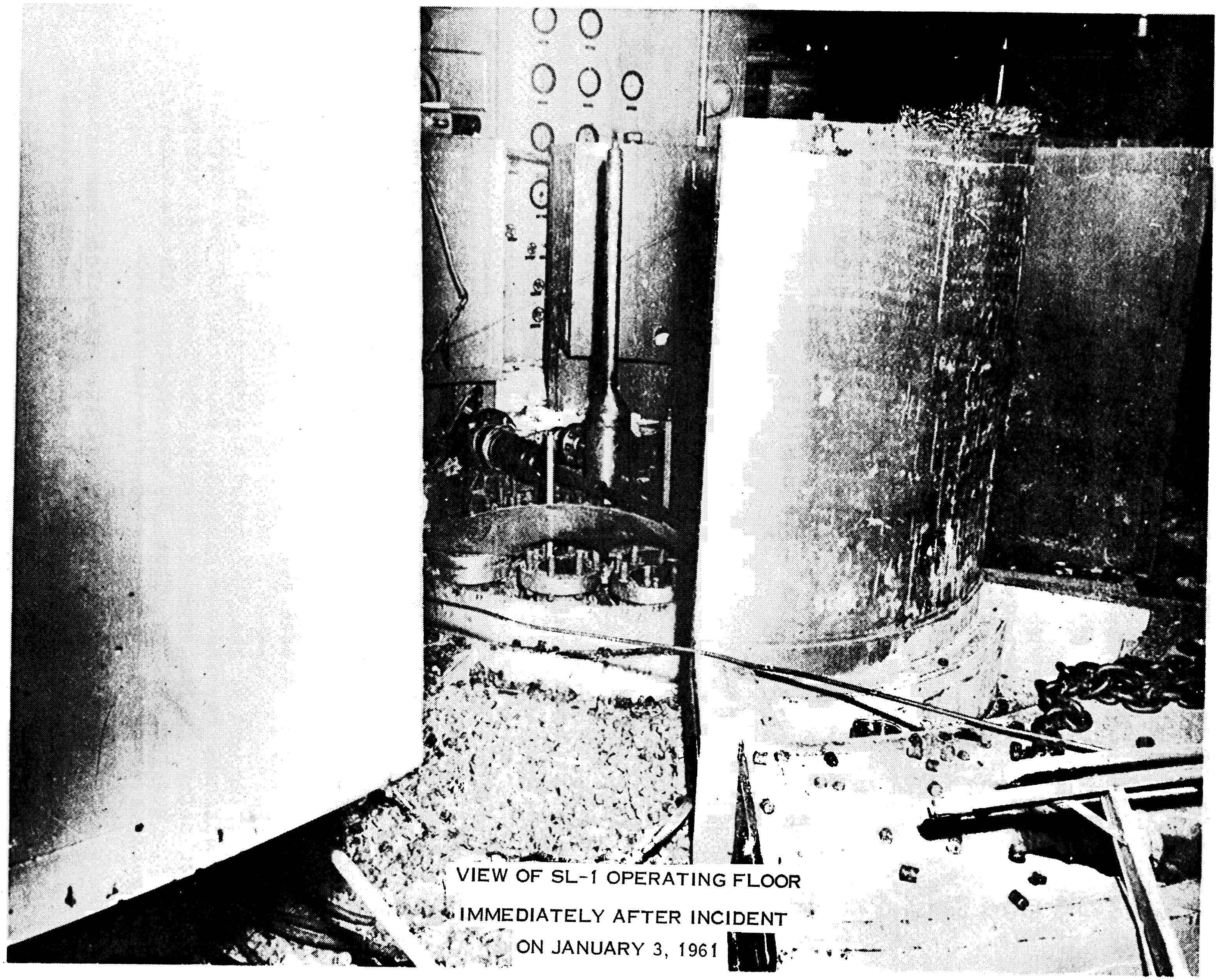

VIEW OF SL-1 OPERATING FLOOR
IMMEDIATELY AFTER INCIDENT
ON JANUARY 3, 1961

FIGURE I-19

2. Radiation Levels

a. Inside Reactor Building

Radiation levels in the Reactor Building just after the incident were accumulated from portable Health Physics instruments and from dosimeters on persons making entries into the building. Initial levels showed a 1000 r/hr field over the reactor and a 500 r/hr field on the reactor floor at the top of the stairs. Although crude, the results from these measurements were substantiated later by more precise survey equipment.

The measurements taken on the reactor operating floor from January 4 through January 30, 1961 are presented in Figure I-20 (7).

b. Outside Reactor Building

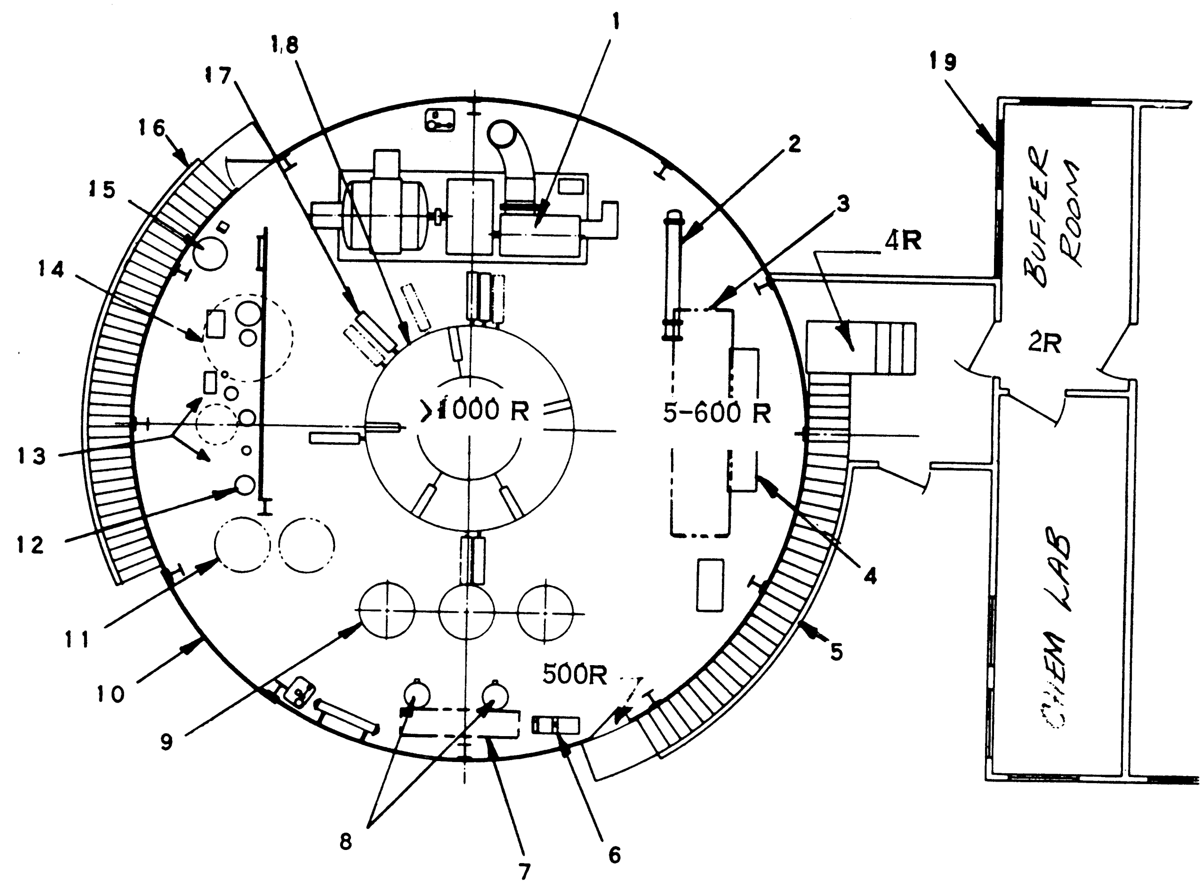
The first comprehensive radiation survey around the reactor building was made on January 7, 1961. From the radiation data, isodose lines have been sketched in Figure I-21 which vary from 10 r/hr at the base of the building to 0.2 r/hr at the fence. The isodose lines show radiation levels in the area in which the emergency operations effort had to be performed.

3. Concern for Another Nuclear Excursion

Initial photographs and testimony of personnel entering the reactor building partially revealed the physical condition of the operating floor and reactor head area. Radiation levels on the reactor operating floor of 500 to 1000 r/hr prevented direct examination of the reactor vessel and core. All nuclear instrumentation was made inoperative by the incident. These factors resulted in uncertainty about the shutdown condition of the reactor.

The evidence of damage on the reactor floor led to the supposition that severe damage had occurred to the core and that appreciable water was expelled from the reactor vessel. It was also known that criticality could result from withdrawal of the center control rod. No information on position of the contact rods with respect to the core was available.

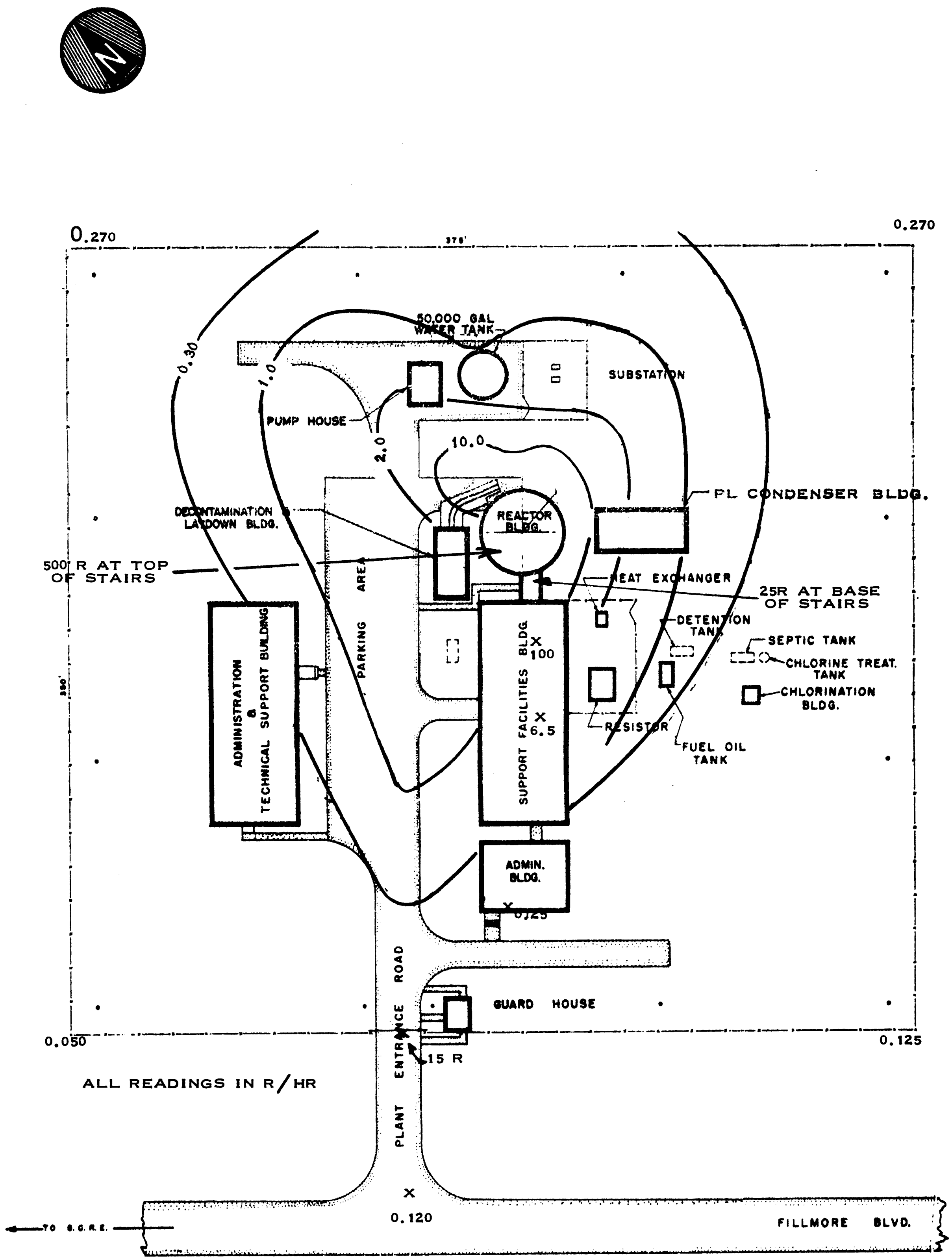
Since the mechanism of reactor shutdown was unknown it was prudent to assume that a distrubance of the core configuration could result in another nuclear excursion and an additional radiation burst. The objective of the next sequence of operations was, therefore, to establish the shutdown condition of the reactor and to deactivate the core if required.



1. TURBINE-GENERATOR
2. HEAT EXCHANGER
3. WATER STORAGE TANK (OVERHEAD)
4. MOTOR CONTROL BOARD
5. COVERED STAIRWAY
6. CONDENSATE CIRCULATING PUMP
7. HOTWELL (OVERHEAD)
8. FEED WATER PUMPS
9. FUEL STORAGE WELLS
10. EQUIPMENT DOORS
11. WASTE STORAGE TANKS
12. FEED WATER LINE FILTER
13. PURIFICATION SYSTEM AREA
14. CONTAMINATED WATER STORAGE TANK
15. BORON STORAGE TANK
16. COVERED EMERGENCY STAIRWAY
17. CONTROL ROD DRIVE MOTORS
18. CONCRETE SHIELD
19. SUPPORT FACILITIES BUILDING (CONTROL ROOM LOCATION)

RADIATION LEVELS INSIDE REACTOR
BUILDING IMMEDIATELY AFTER
INCIDENT

FIGURE I-20



RADIATION MAP OUTSIDE REACTOR BUILDING ON JANUARY 7, 1961

FIGURE I-21

E. EMERGENCY INSTRUMENTATION

SL-1 nuclear instrumentation was made inoperative by the incident. Therefore, a nuclear alarm system was set up to furnish visual and audible alarms for personnel working in the area in case of an unexpected criticality in the reactor. Provision for continuous recording of a fission chamber channel and one gamma channel was included for record purposes in case a criticality should occur. The system established is described in block diagram form in Figure I-26. The location of each component is indicated.

BLOCK DIAGRAM OF THE SL-1 NUCLEAR ALARM SYSTEM

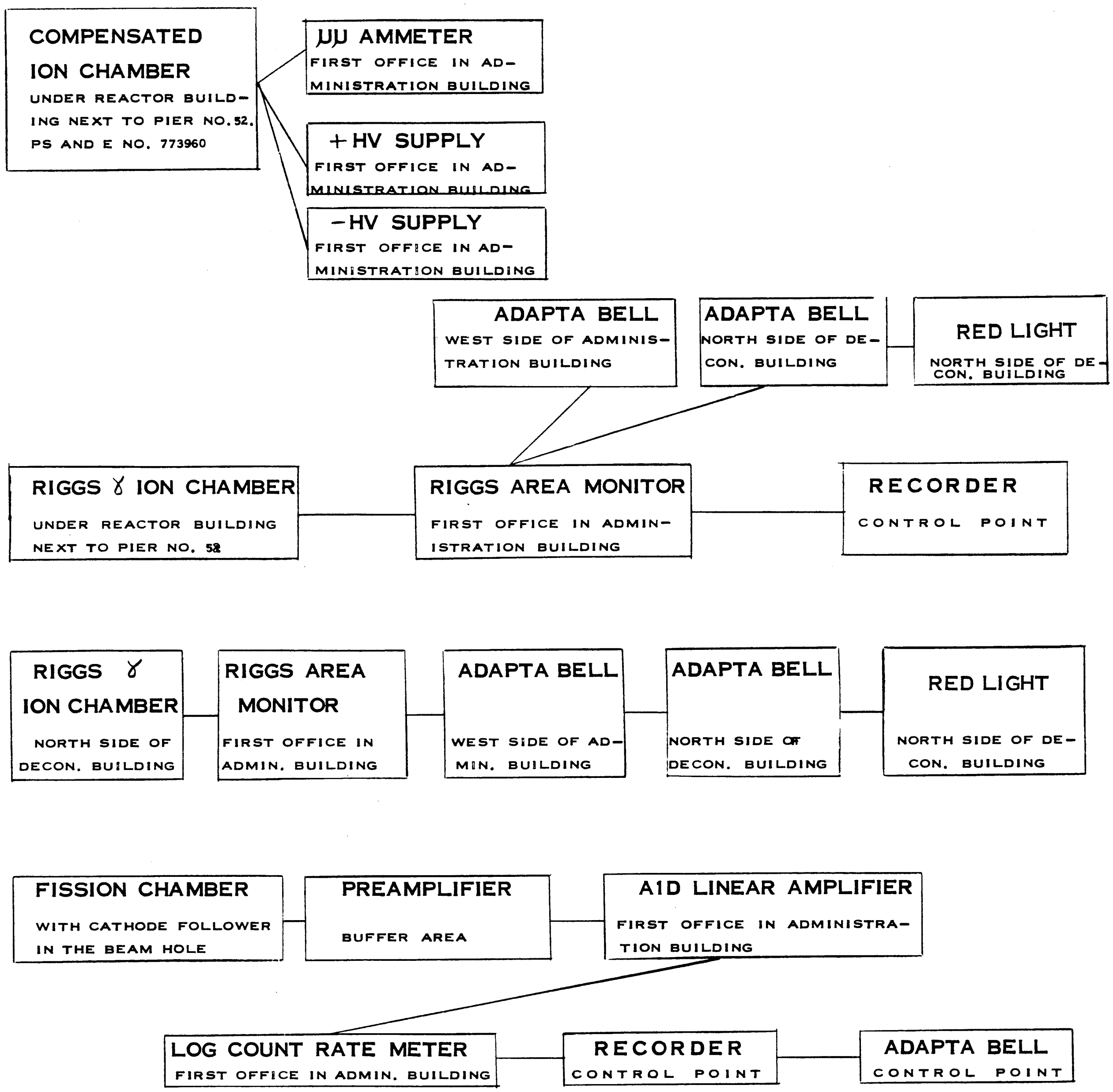


FIGURE I-22

II SL-1 DEACTIVATION

A. OPERATIONS PLAN

Combustion developed and the Commission approved a plan for SL-1 core deactivation. The plan is summarized below:

The guidelines for work covered by the plan were influenced by the consideration that the core may be in a near critical configuration. The possibility that the subsequent operations might disturb a delicate balance could not be discounted. All operations should be conducted to assure minimum disturbance should this condition exist. Therefore, a minimum number of entries into SL-1 involving a limited number of personnel were proposed.

In accord with the above guidelines, the following steps were recommended:

1. Make radiation survey of the site and support buildings.

2. Install neutron and gamma detection and alarm instrumentation in a suitable location to monitor subsequent activities.

3. Obtain a view of the top of the reactor vessel head to determine the access available for penetration into the reactor for further observation of the core condition.

4. Look inside the reactor vessel to determine the condition of the core and possibly to determine the water level optically.

5. Determine the water level mechanically if unsuccessful in Step 4.

6. Deactivate the core by addition of a poison solution.

B. OPERATIONS APPROACH

1. Entries Into SL-1 Facility

High radiation levels in the reactor building and the uncertain reactivity condition of the core and vessel lead to the establishment of several guidelines for deactiviation operations. First, all deactivation tasks would be performed with no personnel access to the reactor building. Second, emergency neutron and gamma monitoring and alarm instrumentation would be installed to replace instrumentation made inoperative by the incident, and to alert personnel working within the SL-1 compound in the unlikely event of another nuclear excursion. Third, radiation dose levels for personnel were established at 2.5 r/quarter.

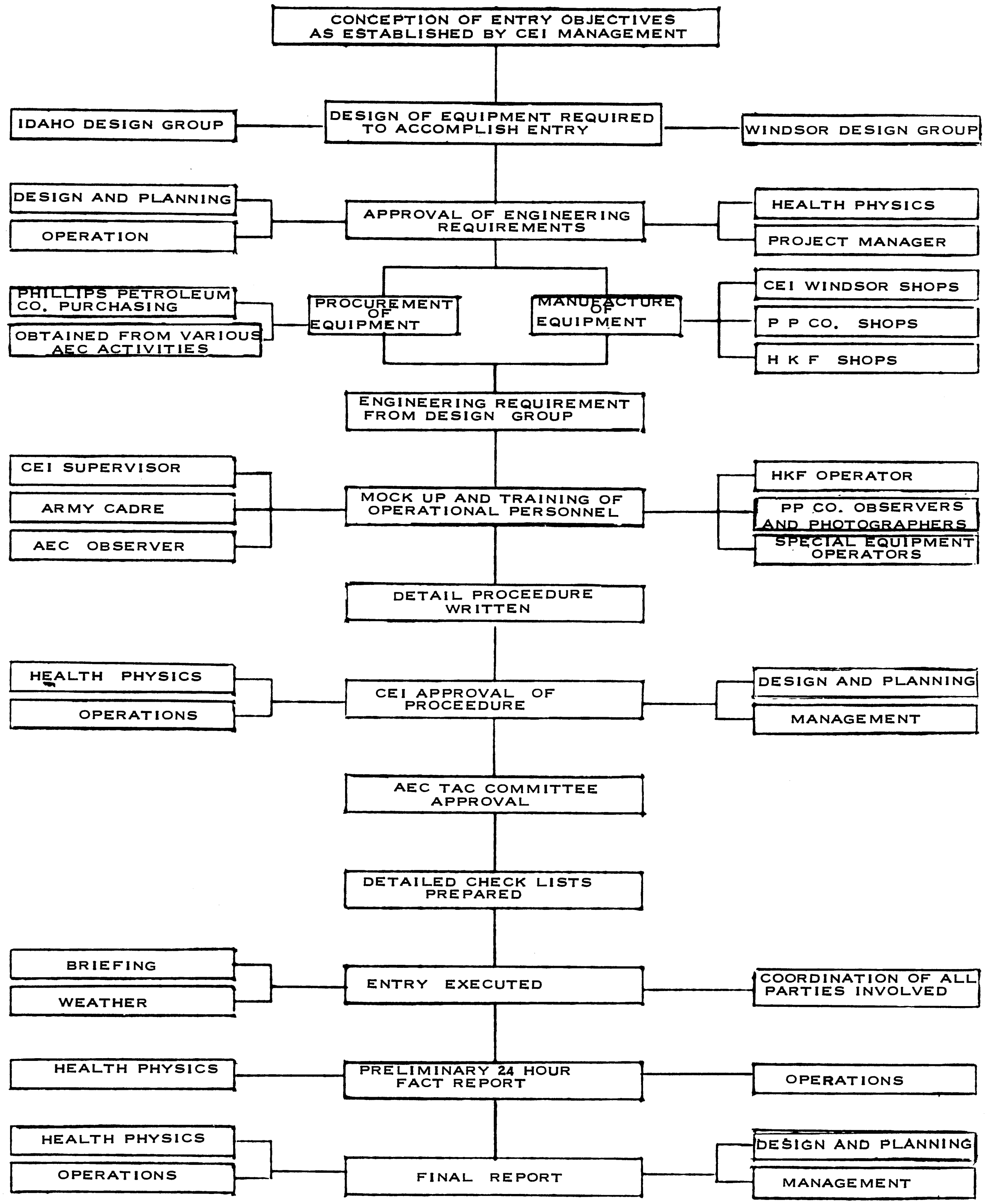
Supporting Combustion in the deactivation effort were several companies and government agencies. A major entry into SL-1 required the performance of some function by all of these organizations. A flow chart which shows the steps of planning and executing an entry is shown in Figure II-1. Routine entries, i.e., instrument checks, did not follow the complete process, but included those steps essential to satisfactory execution.

The planning and execution of each entry was performed in accord with the approved deactivation plan. The objectives for an entry were defined in conjunction with the Idaho Operations Office and its Technical Advisory Committee. Results from earlier entries served as a basis for setting objectives for the next entry.

Design engineers next proceeded to select or design equipment for the new entry. In practice, several equipment schemes were being designed concurrently for one or several entries. After the initial design and planning effort, the most promising apparatus was selected for fabrication or procurement.

Each item of equipment was adapted for use on the mobile crane and boom. Electronic equipment was made shock resistant. Pulleys, wires, light cords, and tag lines were procured and tailored for each individual entry. Brackets for mounting temperature recorders, television monitors, etc. on the shielded crane were fabricated. Typical problems included adapting light cords, television cables, and thermocouple wires to the boom so that each cable would operate freely and independently of each other. In the case of the water level probes, a tape was installed on the crane boom for measuring the distance the cable was played out.

The purchase of equipment was handled by Phillips Petroleum Company. The manufacture of machine parts and structural equipment was completed by the Phillips' shops at Central Facilities. Construction, rigging, and major electrical work was performed by the H. K. Ferguson Company. Special equipment such as television and nuclear instrumentation was provided and assembled by specialists from other AEC activities. All equipment was procured and manufactured under Combustion Engineering, Inc. supervision.



FLOW SHEET FOR ENTRY PLANNING AND EXECUTION

FIGURE II-1

When the equipment was available and bench tested, the operational mockup effort was started. A preliminary operating procedure was prepared to guide testing. The mockup testing served to check out equipment, develop a detailed operational sequence, train operating crews, and provide operating time needed to set radiation doses. The mockup work is discussed in detail in the next section.

After the mockup work was completed, training and review of procedures continued until each man in the operating crew was thoroughly familiar with his particular job. Review of past operations was required.

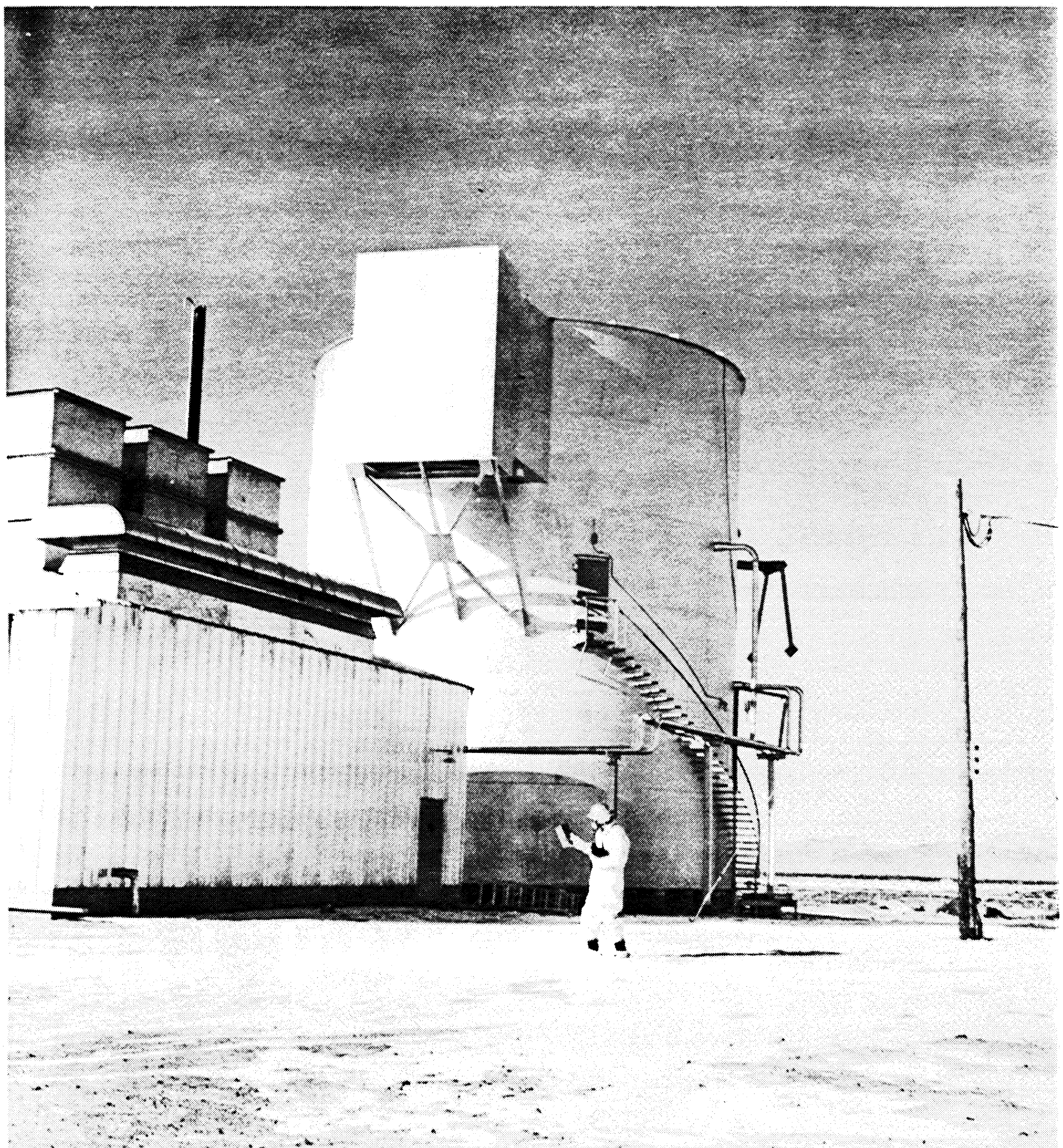
A detailed operating procedure was prepared and submitted for concurrence of the project engineering design section, health physics section, and the Project Manager. After concurrences were obtained, the procedure was assembled in final form and submitted to the Idaho Operations Office for final approval.

The AEC, Idaho Operations Office, assigned supervisory and operational responsibility to Combustion Engineering for the deactivation operation. However, the Commission retained approval authority for each entry procedure as well as for the general operational plan. Initially, the Commission staff and its Technical Advisory Committee held hearings on entry procedures at which Combustion Engineering presented a review of equipment and techniques to be used. This step resulted in the formal submission of each entry procedure, formal review, and formal documentation of entry approval.

With the procedure approved, a time and date for the entry was assigned. Weather was an important consideration in scheduling entries. Snow and freezing temperatures were common during the early entries. In later operations rain, wind, and dust were contended with. With the time and day designated, equipment and personnel were assembled at the Control Point four hours prior to the entry. All effort from this point was coordinated by the Combustion Engineering supervisor in charge of the entry. The personnel included H. K. Ferguson heavy equipment operators, Army Cadre and Combustion Engineering equipment operators, H. K. Ferguson electricians, Army photographers, special equipment operators, AEC observers, the Combustion Engineering entry supervisor, and Combustion Engineering health physicists.

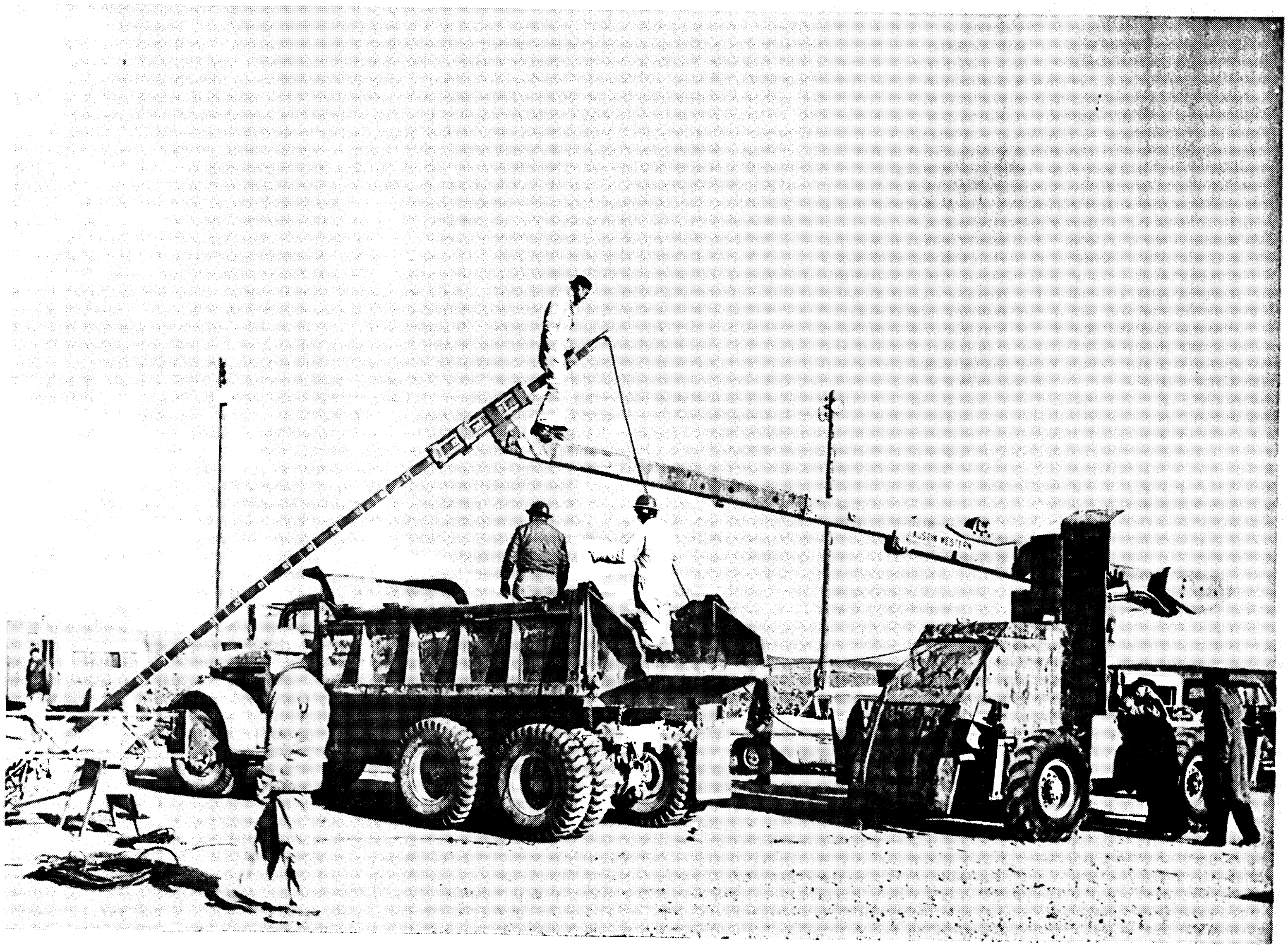
Following transfer of equipment from the mockup to the Control Point, the final assembly, rigging, and check-out of apparatus is performed (Figure II-3). Radiation detectors are attached to the crane rig.

Personnel involved in the entry are dressed in protective clothing under health physics supervision and issued dosimeters and film badges. Upon completion of dressing, personnel involved in the operation attend an Operations and Health Physics briefing (Figure II-4). The briefing covered the following subjects:



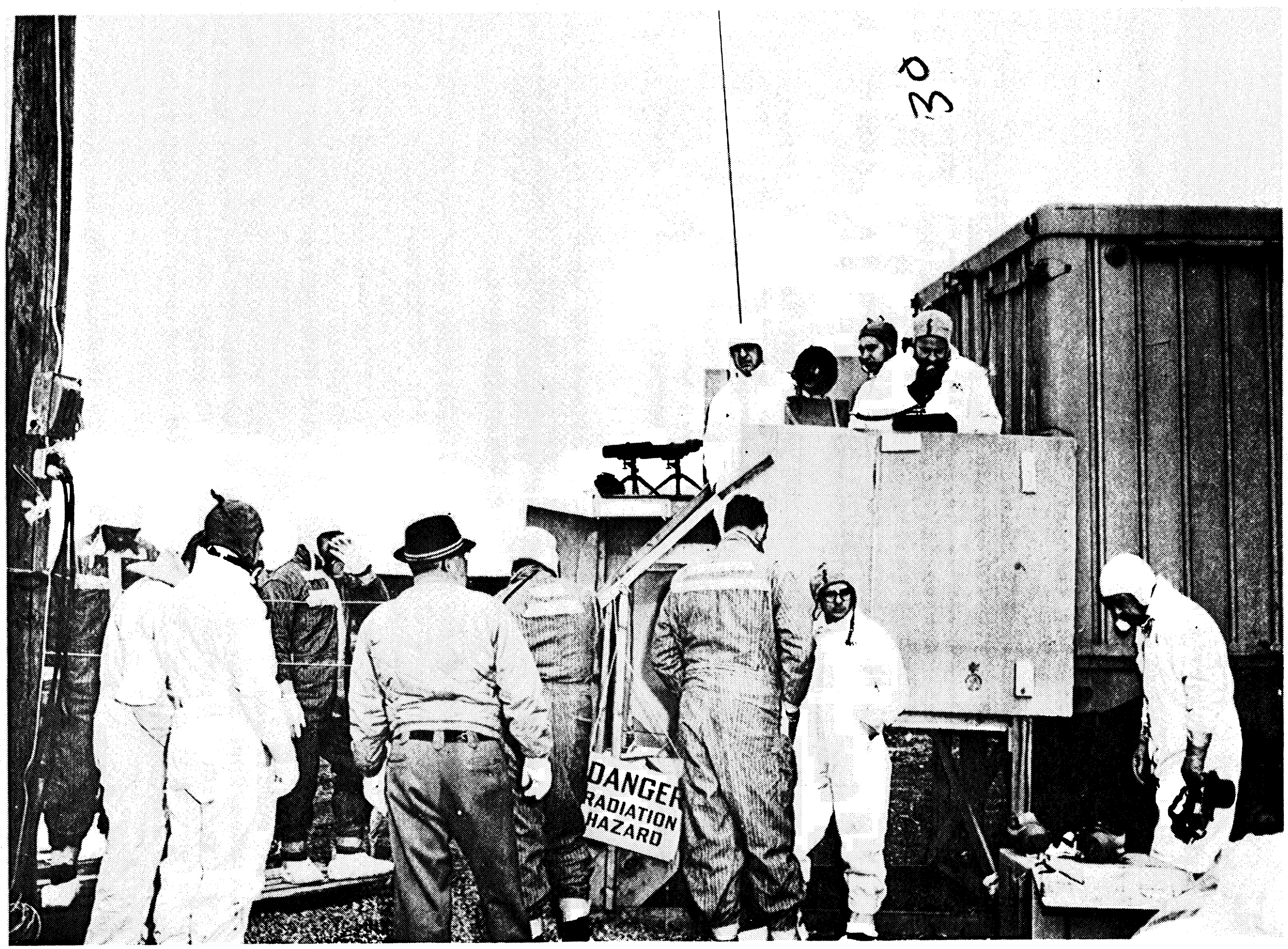
HEALTH PHYSICS MONITOR PERFORMING SITE SURVEY

FIGURE II-2



EQUIPMENT CHECK OUT AT CONTROL POINT BEFORE ENTRY

FIGURE II-3



BRIEFING THE ENTRY CREW

FIGURE II-4

a. Radiation levels expected.

b. Alarm system and evacuation routes.

c. Supervisory control of the entry.

d. Vehicle assignments for transportation to and from the Site.

e. Review of the detailed entry procedure.

Following a schedule determined by the entry supervisor, crews are dispatched to the site to survey the area and monitor nuclear instrumentation (Figure II-5), open cargo doors (Figure II-6), drive heavy equipment to the Site (Figure II-7), occupy the spotting tower for guiding equipment (Figure II-8), make electrical tie-ins, establish a point for photographing the operation, and perform entry in Reactor Building (Figure II-9).

A Combustion Engineering health physicist accompanied each entry to control radiation exposures of entry participants. He had the authority to halt the operation whenever the estimated exposures were exceeded. During the entry, personnel not necessary for the operation conceal themselves behind temporary shields (Figure II-10), and nuclear instrumentation is constantly monitored.

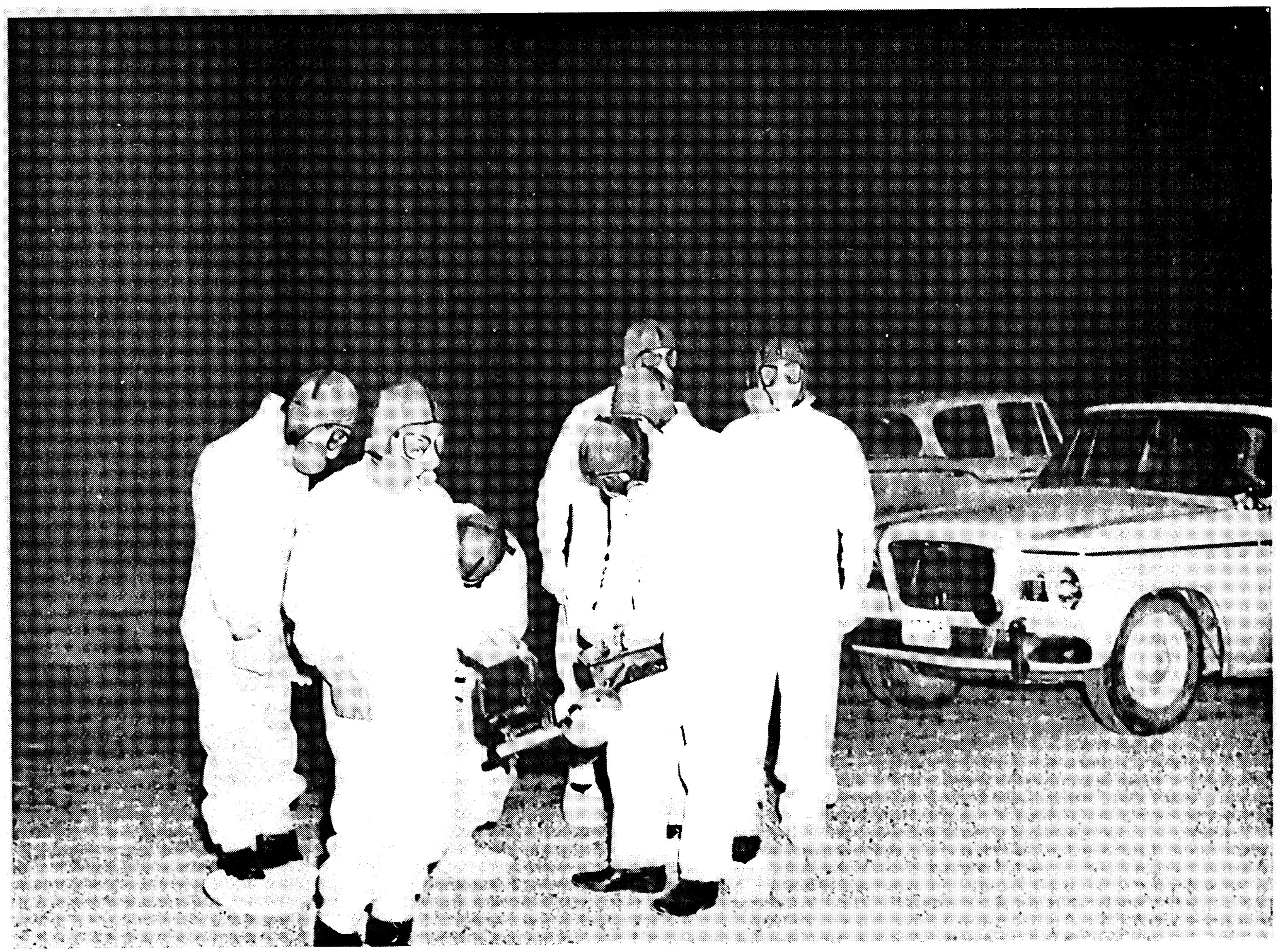
Upon completion of the entry objectives and when directed by the entry supervisor, all personnel return to the Control Point. The door opening crew which had returned to the Control Point, makes the final entry to close the cargo door.

Upon their return from the plant, personnel wait in the gray area at the Control Point until the results of the entry are initially verified, whether it be the exposure of film or water probe examination, etc. Samples, equipment, and film removed from the reactor building are decontaminated at the decontamination point. Personnel are undressed, monitored, and checked through the Control Point.

The personnel dosimeters are read and recorded, and the film badges collected for immediate processing by the AEC Personnel Metering Section. An operation was considered completed only after SL-1 Site was secured and all individuals decontaminated and film badges accounted for.

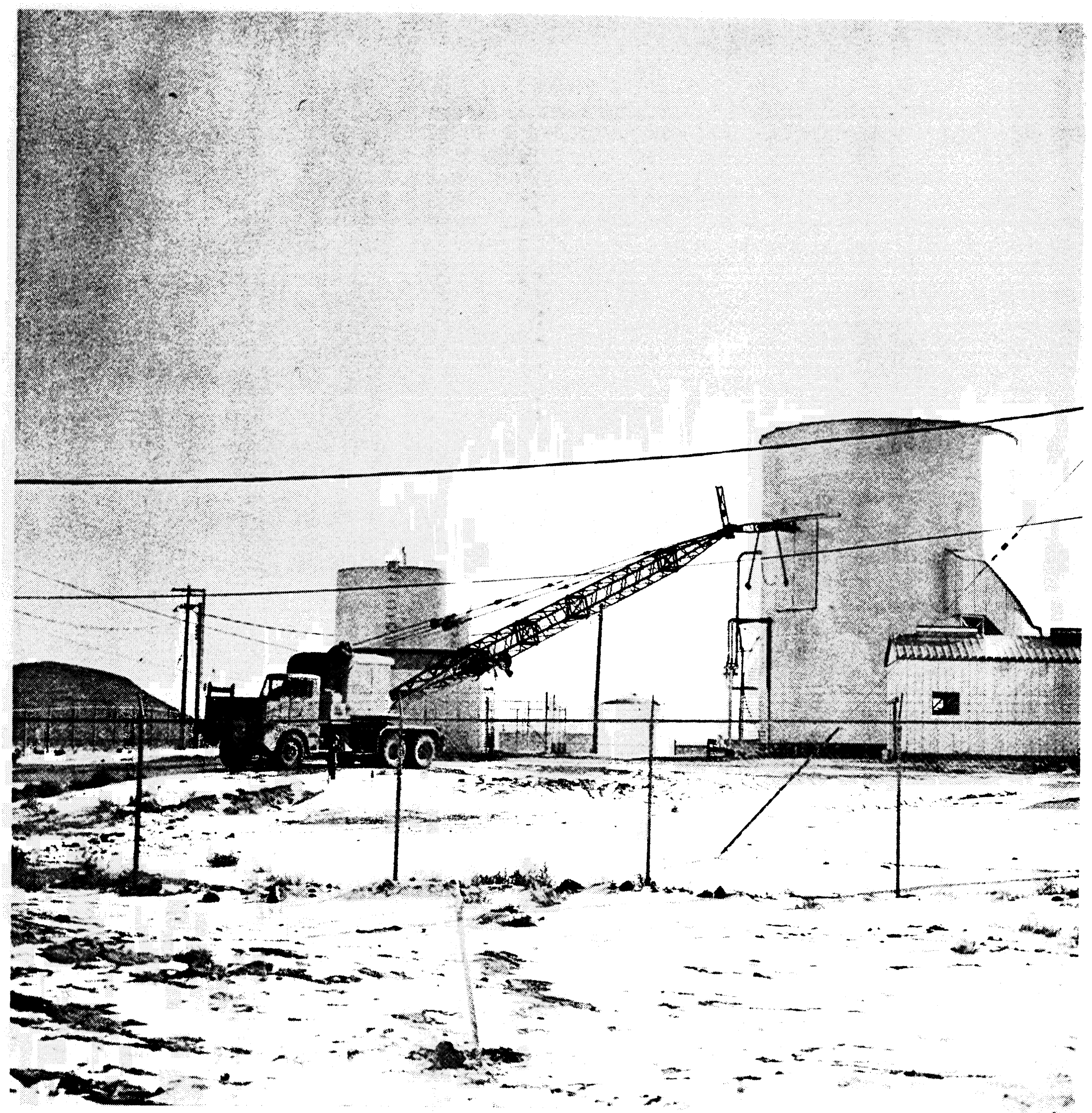
A typical detailed entry procedure is included in the appendix of this document.

A data summary report of the entry was issued by CEI to the AEC for each entry. This report presented facts obtained from the entry.

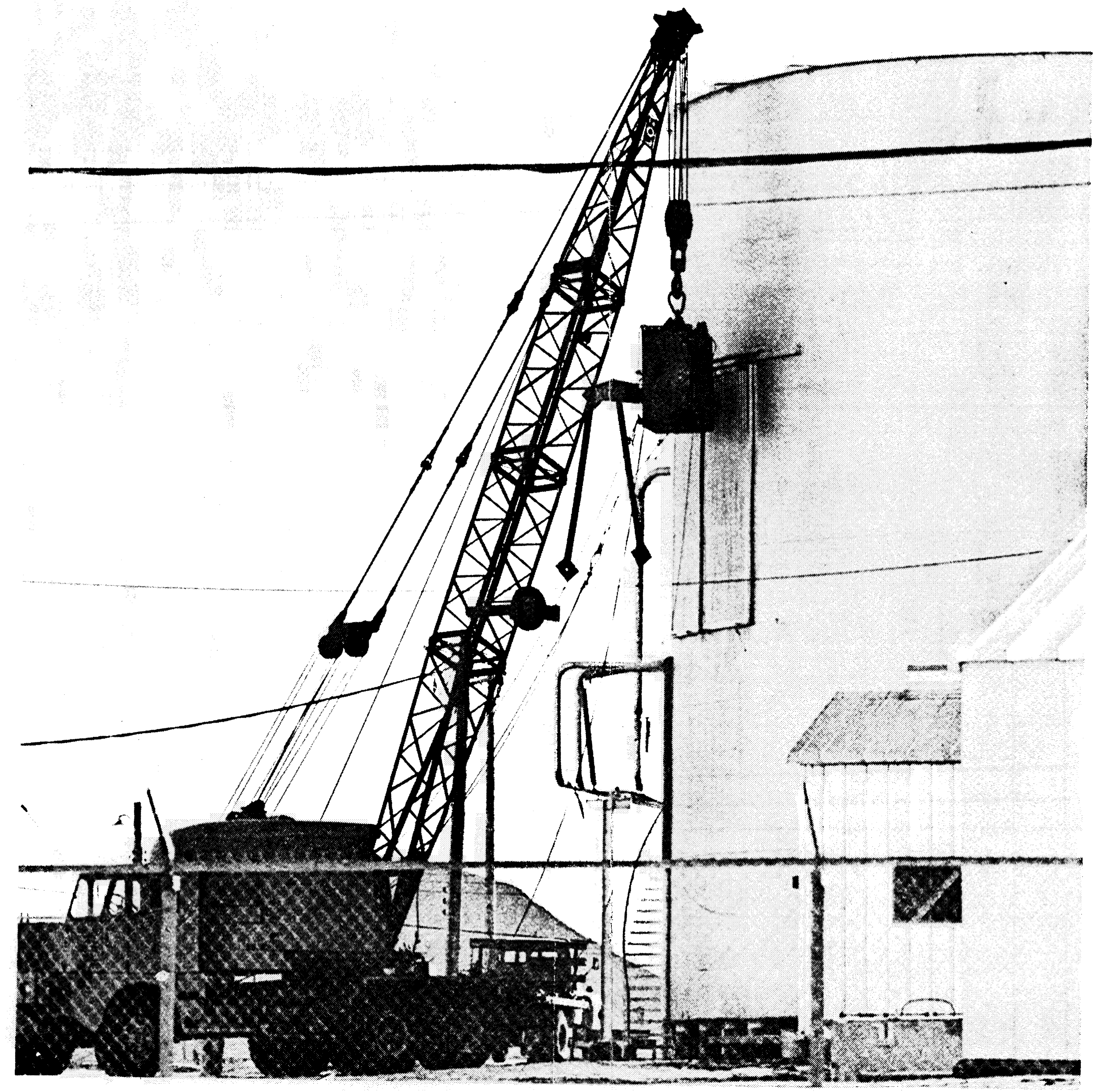


DISPATCHING OF CREW FROM CONTROL POINT

FIGURE II-5



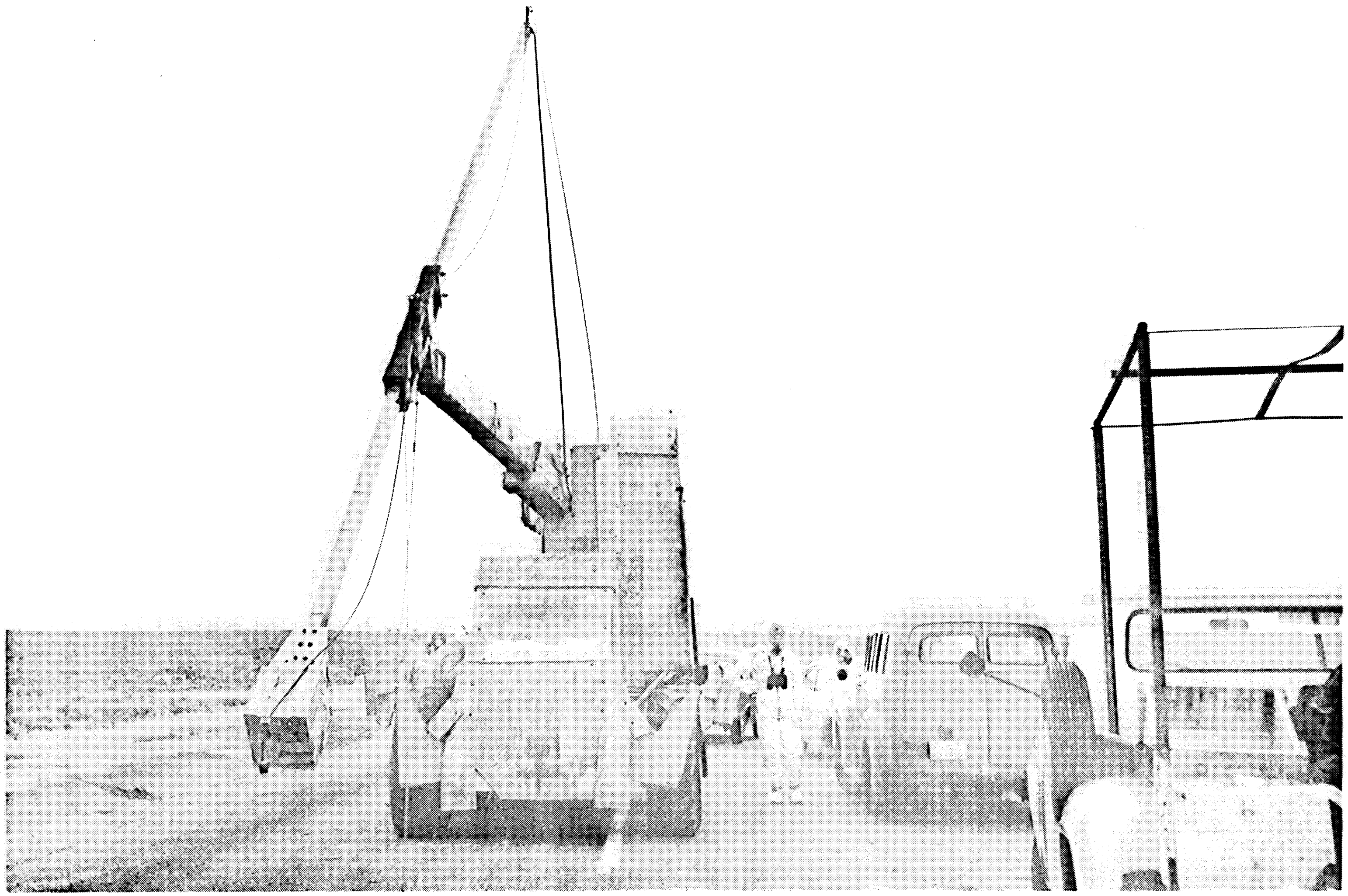
OPENING SILO FREIGHT DOORS USING WEDGE TOOL ATTACHED TO 60 TON CRANE



WELDER IN SHIELDED COFFIN CUTTING MONORAIL BEAM TO EASE DOOR OPENING AND EQUIPMENT ENTRY TO OPERATING FLOOR

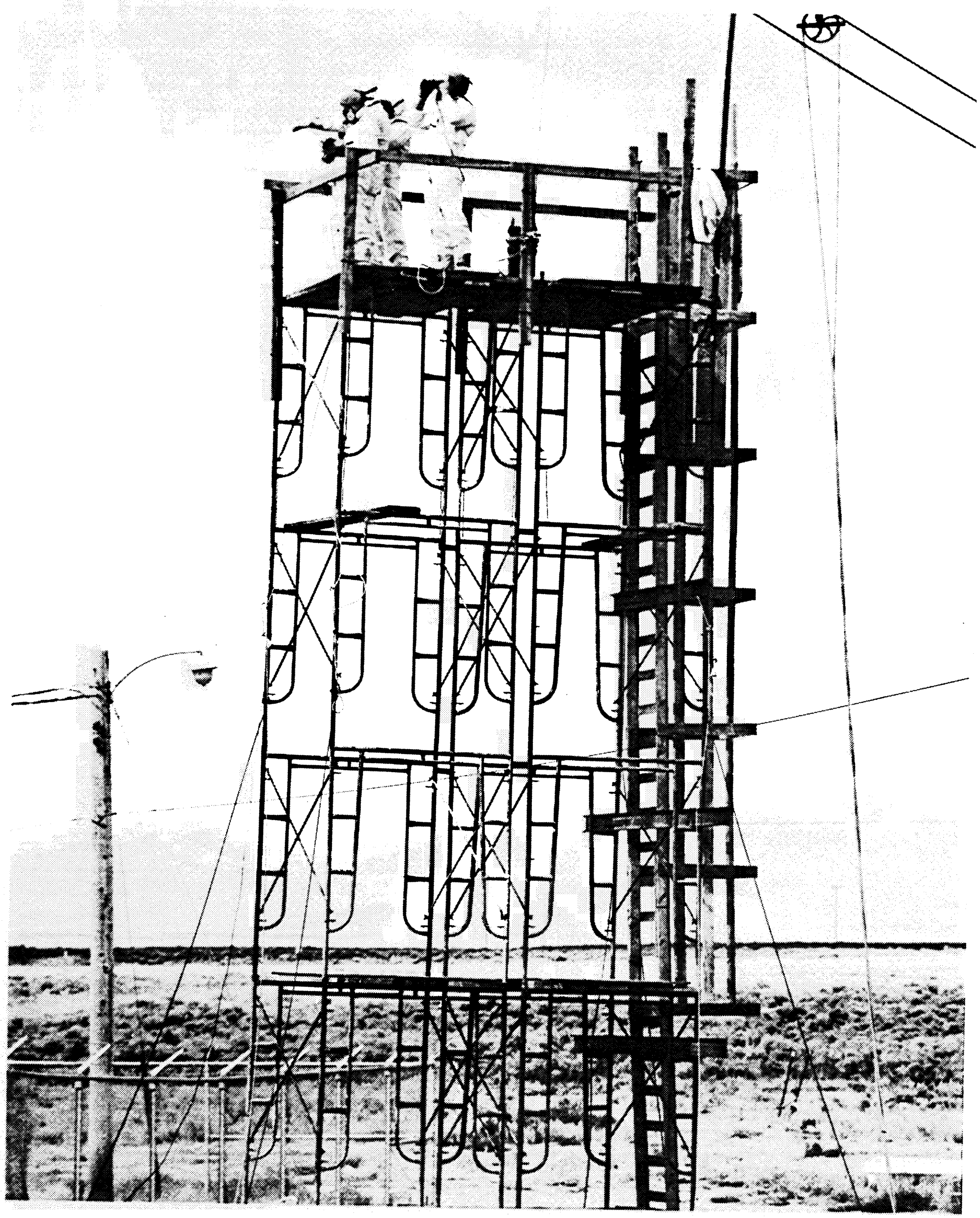
OPENING SL-1 SILO DOORS

FIGURE II-6



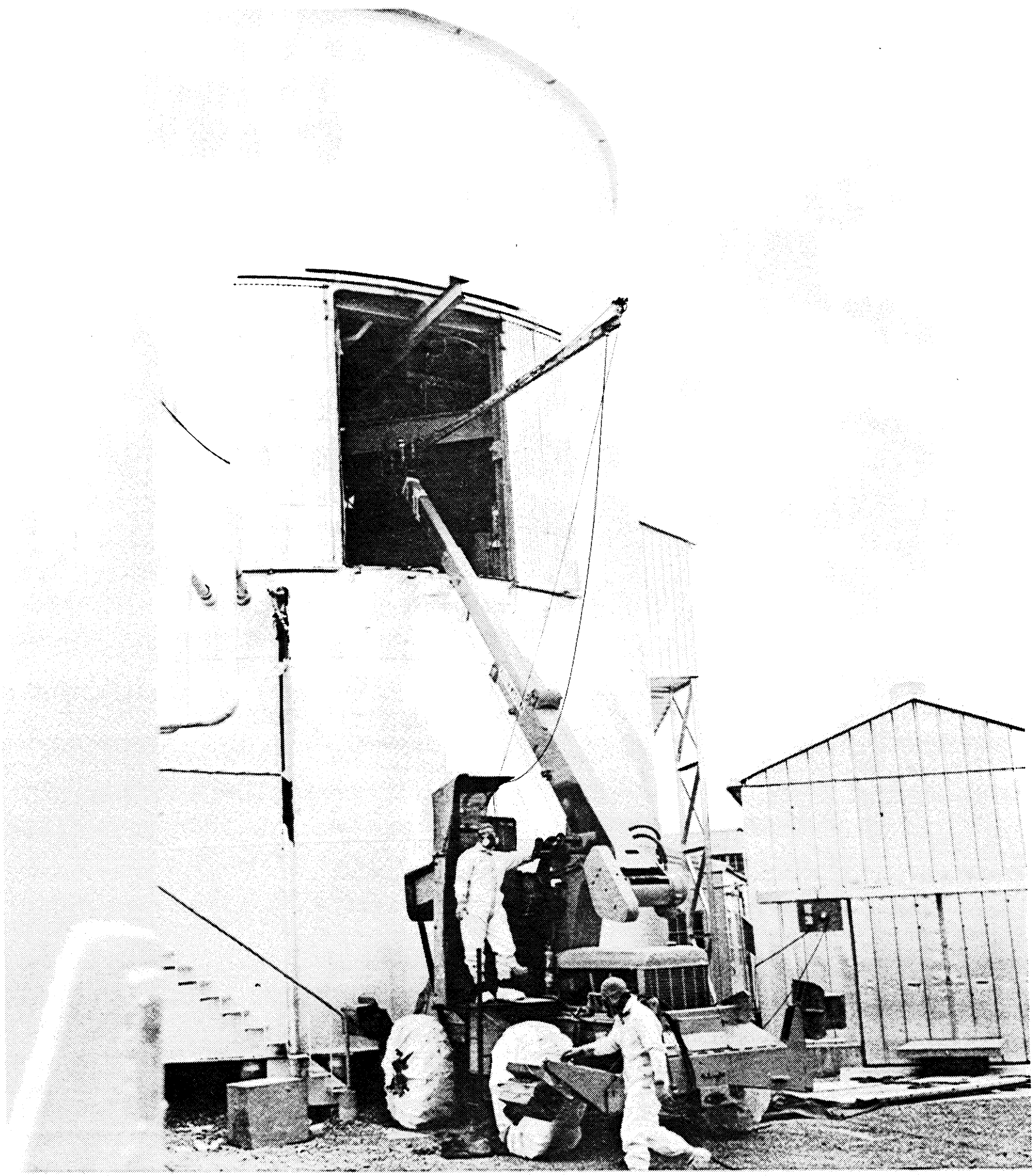
MOVING EQUIPMENT AND PERSONNEL VEHICLES TO SL-1 SITE

FIGURE II-7



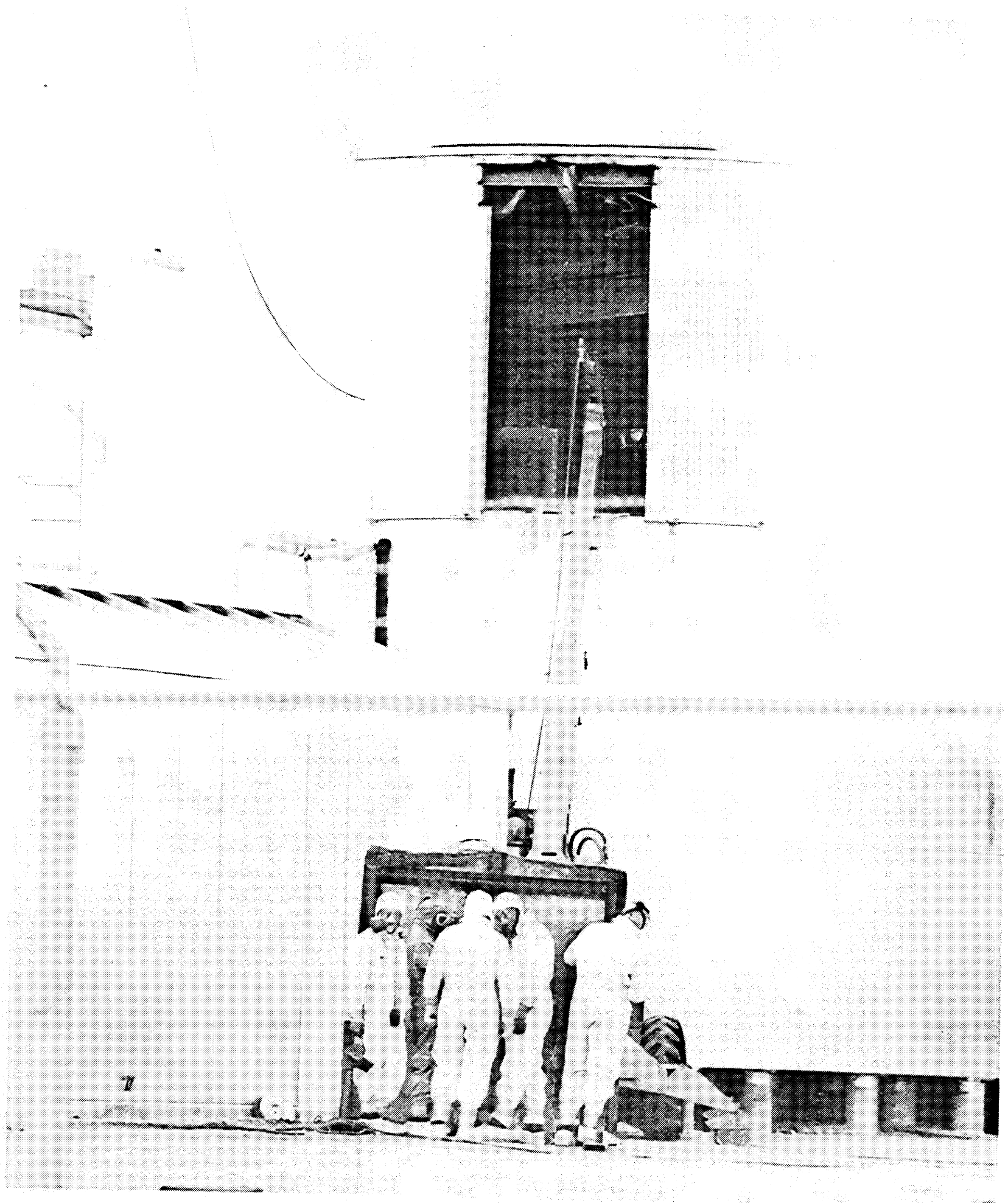
SPOTTING TOWER CREW DIRECTING THE POSITIONING OF THE CRANE AT SL-1 SITE

FIGURE II-8



PERFORMING AN ENTRY INTO THE SL-1 REACTOR BUILDING

FIGURE II-9



SHIELDED OBSERVATION POST

FIGURE II-10

The information is based on a review of photographs and data, development of radiation measuring film, and eye witness accounts. An operational report of major entries was prepared which included analysis of operational methods and equipment performance, personnel radiation summary, photographs of significant operations, and sketches of equipment. Examples of both the date and operational reports may by found in the appendix of this document.

2. Use of Mockup for Testing and Training

The need for a mockup to develop entry techniques and to train personnel was recognized when the guideline was established that deactivation operations would be conducted by remote methods. An AEC fire fighting practice tower, with platforms 24 feet and 40 feet above ground level, was made available as the base structure for the mockup.

The first SL-1 facility simulation was of the SL-1 operating floor, the cargo door, the overhead crane rail, and No. 5 control rod housing mounted on a crude reactor vessel head (Figure II-11). The mockup provided all obstructions known to exist between the cargo door and the reactor vessel head region. Entry operations in the reactor room were, therefore, simulated in the mockup until detailed procedures were developed and equipment was found to function properly and reliably.

Entry operations tested on the mockup as described above were:

a. Entry to traverse the reactor vessel head with a 16 mm motor operated movie camera.

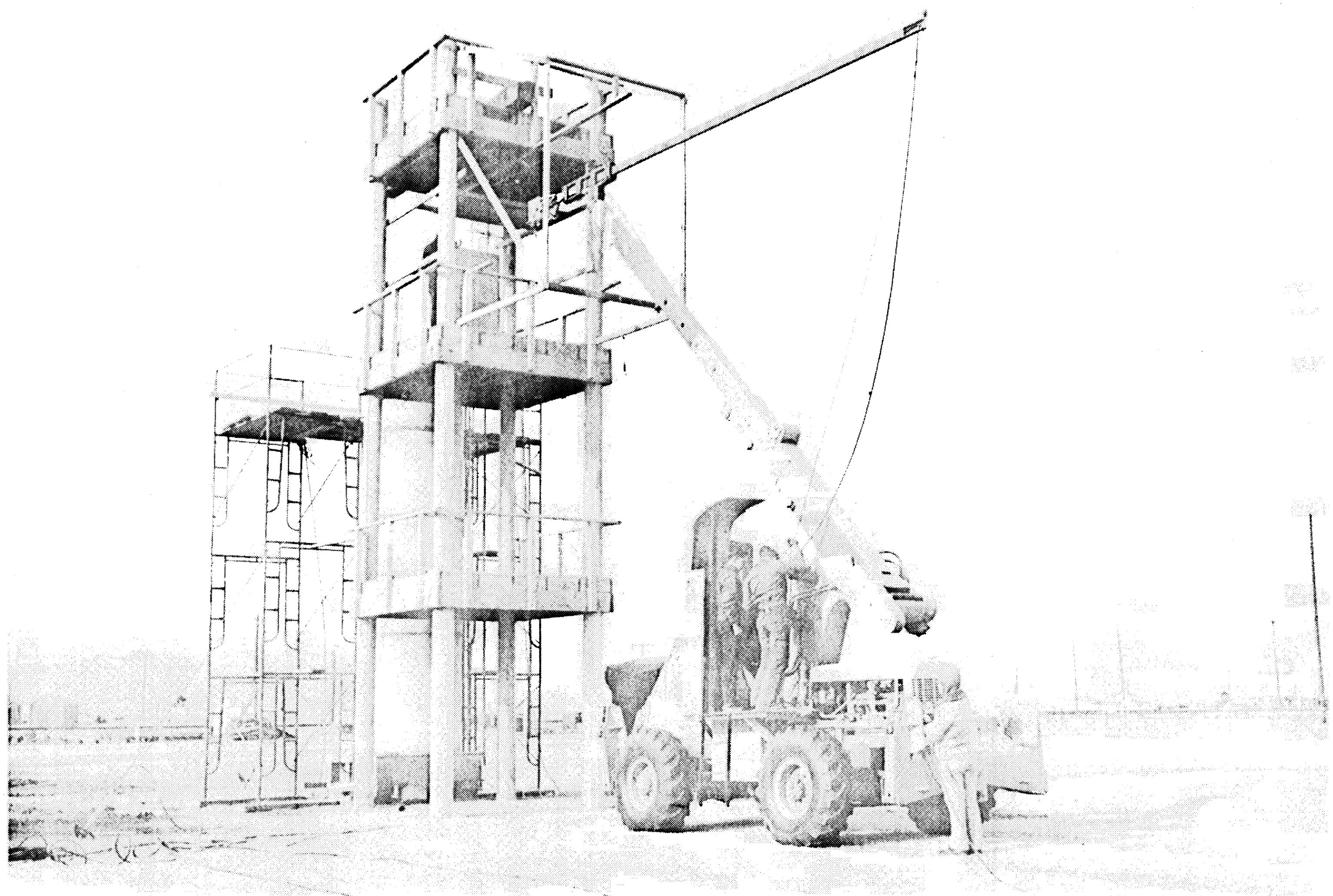
b. Entry for traversing the reactor vessel head with a television camera.

The second phase of the mockup development consisted of adding a simulated reactor vessel (Figure II-12). Concrete pipe sections were built up to satisfy the vessel dimensional requirements and to permit filling with water. A detailed mockup of the reactor vessel head with the damage condition and debris as existed at SL-1 was added (Figure II-13).

Since operations at the SL-1 were done remotely and in many cases without direct viewing, it was necessary to position the probes and cameras over the reactor vessel head with considerable accuracy. It was possible to develop precise traverse patterns for the movable crane boom. Equipment such as the television camera, droplight, and water and temperature probes, could be positioned directly over an open control rod nozzle and dropped into the reactor vessel without direct viewing. Pictures of exact locations could be taken with this technique. The observation tower was added to the mockup facility so that initial lining up of the crane and boom were performed with a high degree of precision.

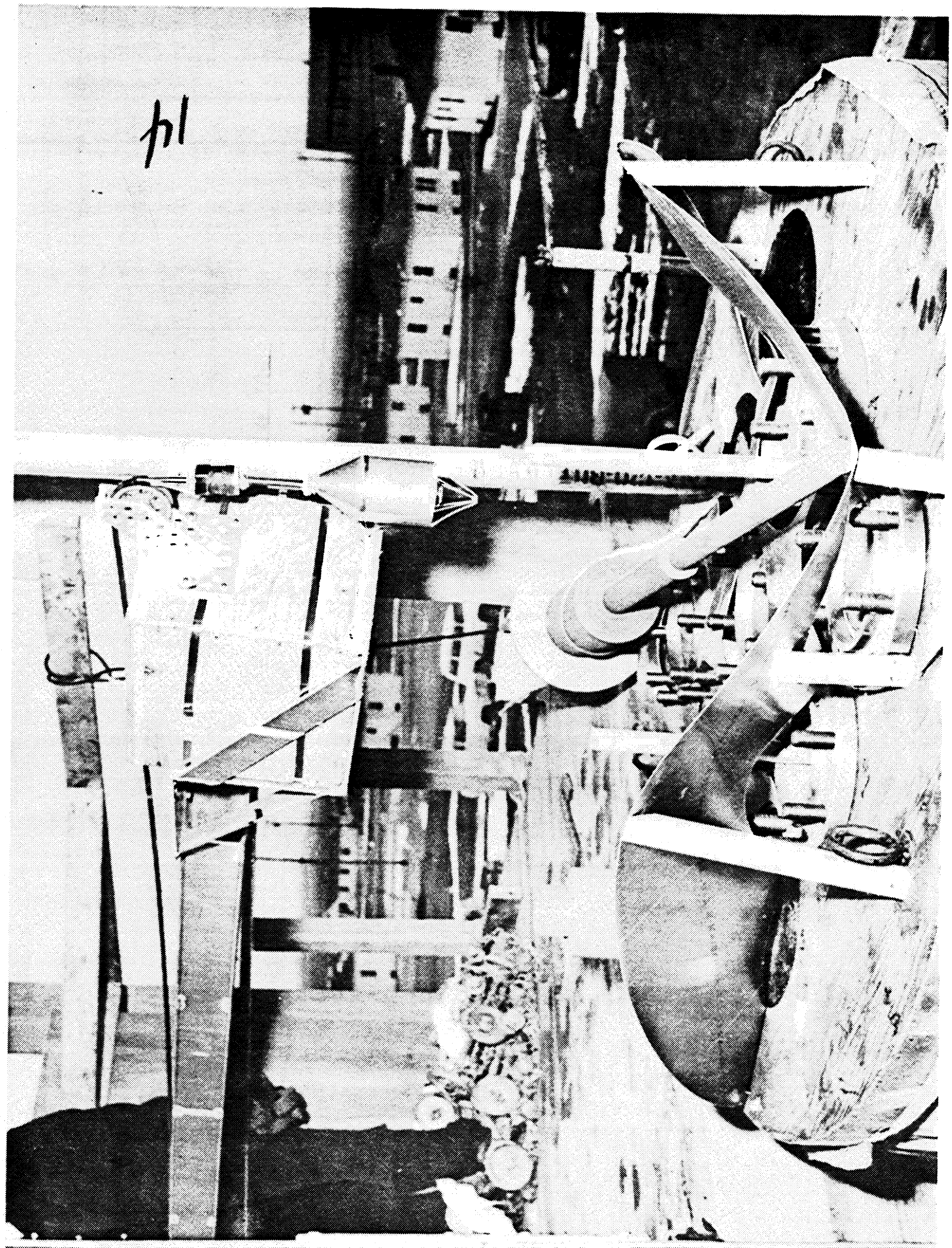
INITIAL MOCKUP OF ACCESS DOOR TO SL-1 REACTOR OPERATING FLOOR

FIGURE II-11



MOCKUP OF SL-1 OPERATING FLOOR AND REACTOR VESSEL HEAD

FIGURE II-12



MOCKUP OF SL-1 REACTOR VESSEL HEAD CONDITION FOLLOWING INCIDENT

FIGURE II-13

Procedures developed during this stage of mockup construction were:

a. Entry for inserting a television camera and droplight into the reactor vessel for core viewing.

b. Entry for detecting water level above the core structure with electrical conductivity and sonic probes.

The third stage in the mockup simulation was the construction of the damaged core structure as observed from SL-1 core pictures. An egg crate structure, control rod extensions, displaced spray rings, No. 8 control rod shrouds, and thermal shield were added. Finally, a model consisting of four fuel elements was placed under No. 8 control rod nozzle. Figure II-14 is a picture of the core mockup.

Entry operations developed during this stage of the mockups were:

a. Entry to lower a water sensitive chemical probe through reactor core structure to locate water.

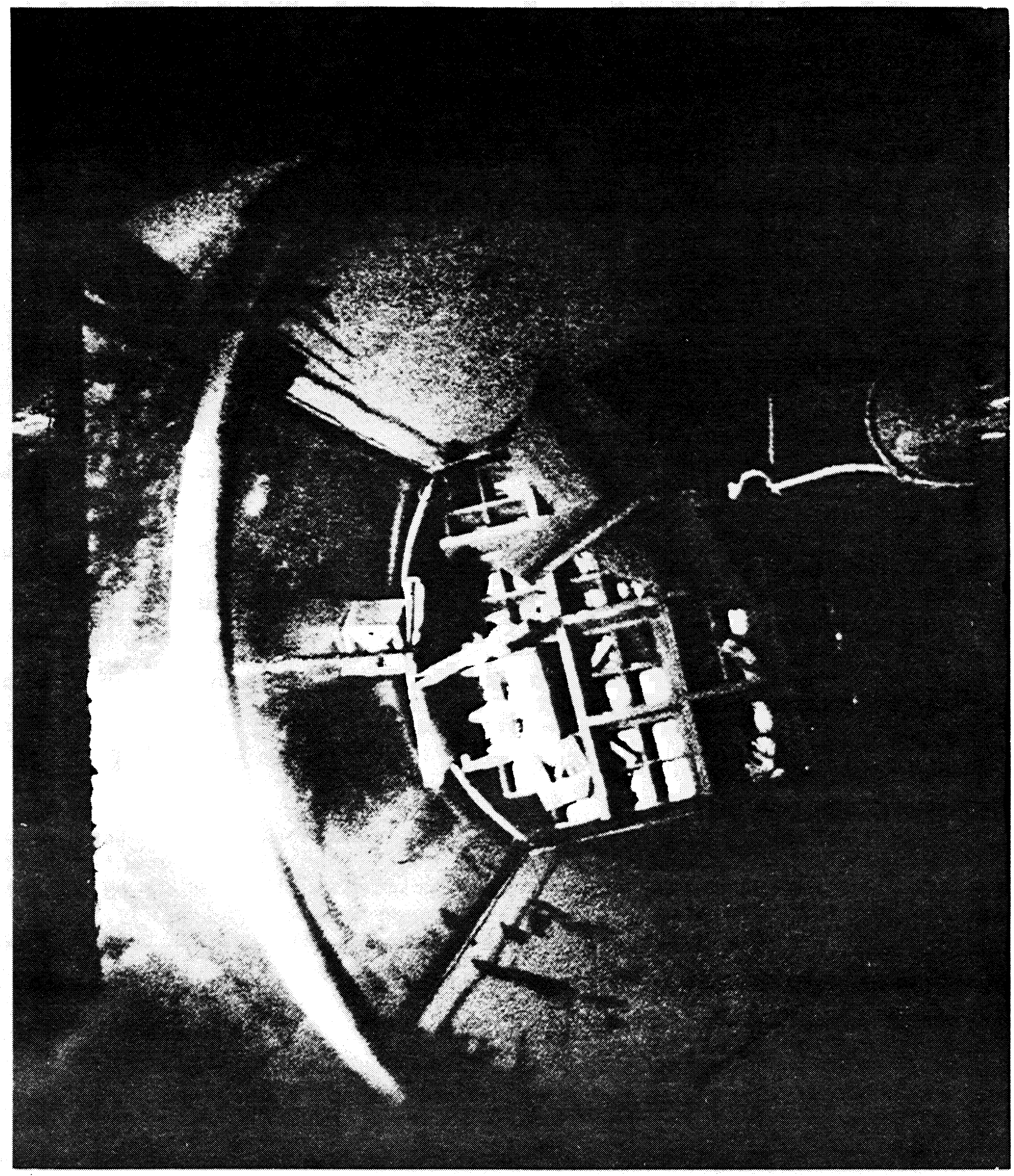
b. Entry to lower temperature probe to top of core structure.

c. Procedure for lowering a vacuum sample collector into reactor vessel.

d. Procedure for lowering a miniature camera assembly into reactor vessel for core viewing.

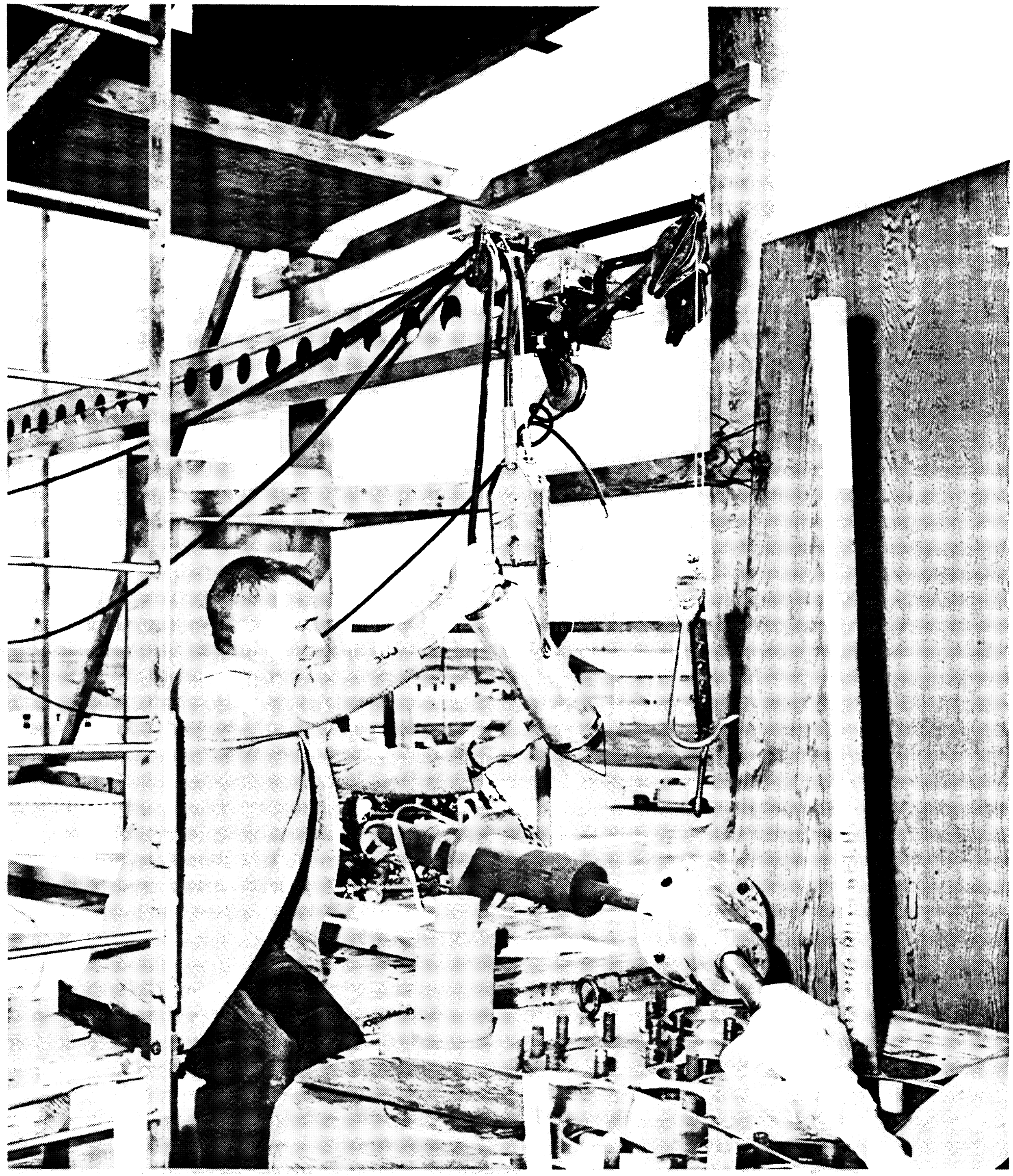
e. Procedure for recovering a shield plug from the top of reactor vessel head.

The mockup was a valuable operational training aid. Operators were acquainted with entry equipment and conditions to be encountered at the SL-1 facility without exposure to radiation (Figure II-15). The mockup permitted the development of operational proficiency, which resulted in repeated successful entries and low personnel exposures.



MOCKUP OF SL-1 CORE STRUCTURAL CONDITION FOLLOWING INCIDENT

FIGURE II-14



USE OF SL-1 MOCKUP TOWER TO TRAIN OPERATORS AND TEST METHODS

FIGURE II-15

C. SPECIAL EQUIPMENT DESIGN

A shielded Austin-Western crane with a specially designed travelling boom was basic to most major entry procedures. Photographic equipment, television camera, grapling hooks, temperature and water probes, and vacuum sampling bottles were suspended from the boom and inserted into the building or, the reactor itself. Wherever possible, commercial equipment was adapted to the particular operation. Special equipment was designed and fabricated as needed.

1. Crane and Mobile Booms

To carry out operations from the outside of the Reactor Building a crane with a travelling boom was used for penetrating the reactor operating room.

The crane was an Austin-Western hy-loader hydraulic unit of 5 ton capacity. The driver was shielded by 1½ inches of lead sheet covering the cab. An additional lead shield was provided for the boom operator and consisted of a canopy of lead sheel approximately one inch thick. The hydraulic boom elevates to 65°, telescopes out eight feet and rotates 360°.

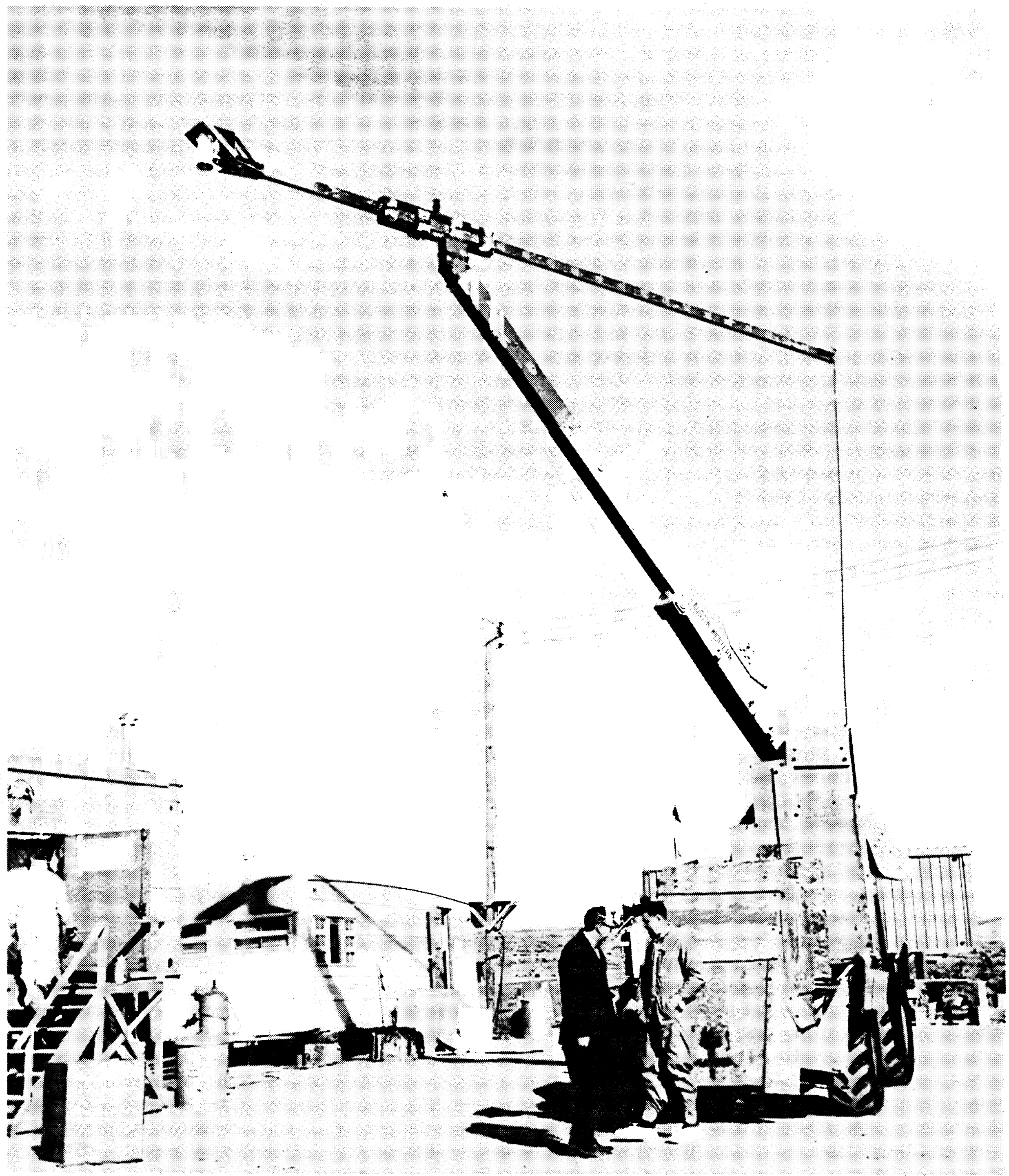
A 200 pound capacity mobile boom, 25 feet long, fabricated from a four inch aluminum I beam reinforced with two 1/8 inch aluminum plates welded along both sides of the flanges was attached to the hydraulic crane boom. This boom was manually operated by a winch and cabling system which allowed the boom to slide in or out (Figure II-16). Cameras, probe, lights, and other equipment were suspended from the sliding boom during remote entries into the reactor room and vessel.

A second mobile boom having a 1,000 pound capacity and 25 foot reach was designed and fabricated (Figure II-17). The boom was motor operated, Figure II-18 and controlled by a start-stop switch located at the crane cabin.

2. Movie Camera and Shielded Box

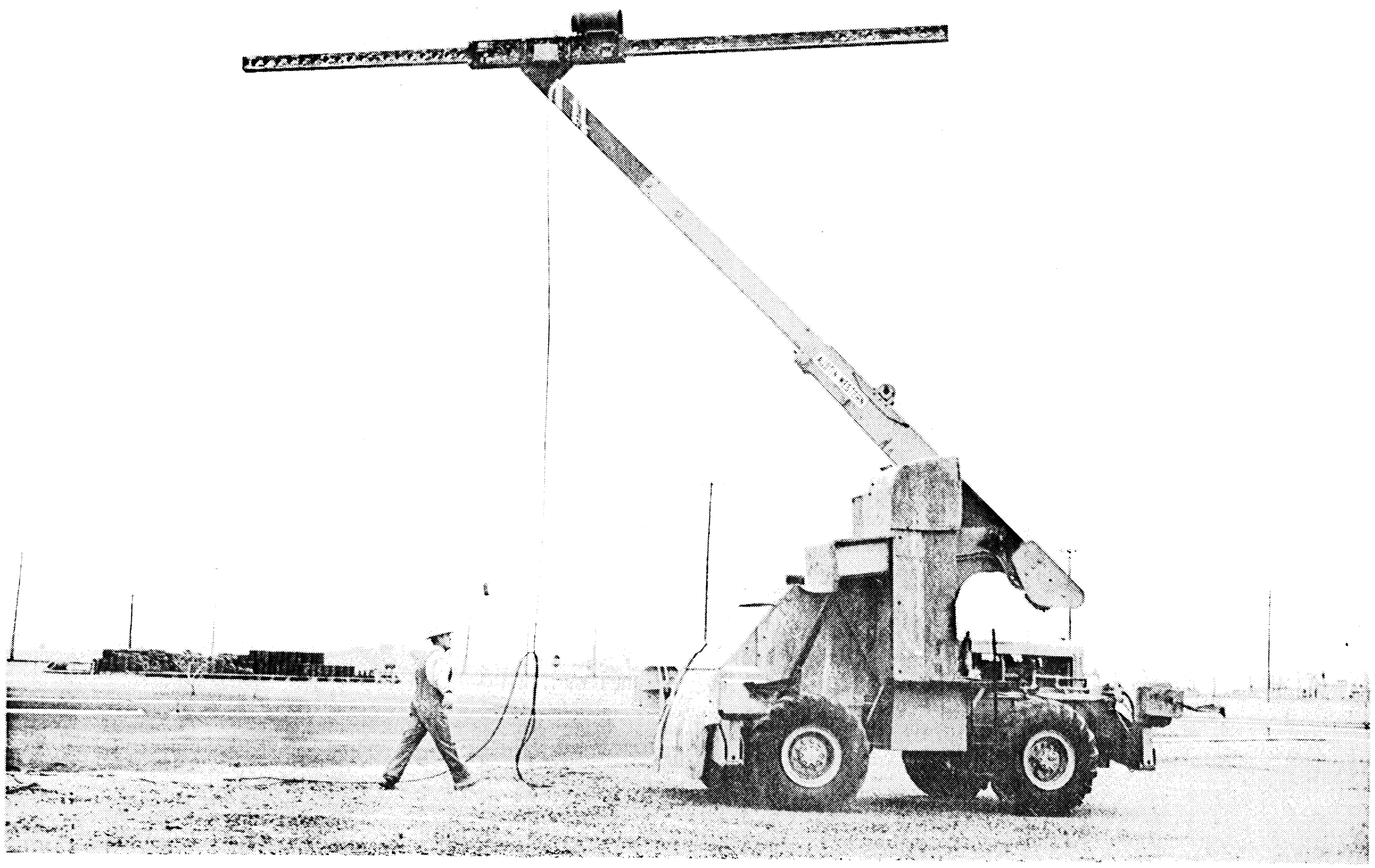
Several entries involved the use of motion picture equipment in high gamma fields. Shielding to prevent film fogging was required, as well as adequate lighting.

A Bell and Howell 16 mm movie camera equipped with electric drive motor was assembled into a system for remote viewing of the reactor area. Both wide angle and standard lenses were provided for special applications. A shielded box was designed to house the camera and drive motor to minimize gamma fogging of film (Figure II-19). The bottom of the box was shielded with 1½ inches of lead and one-half inch of lead was placed on the sides and top of the box. The total



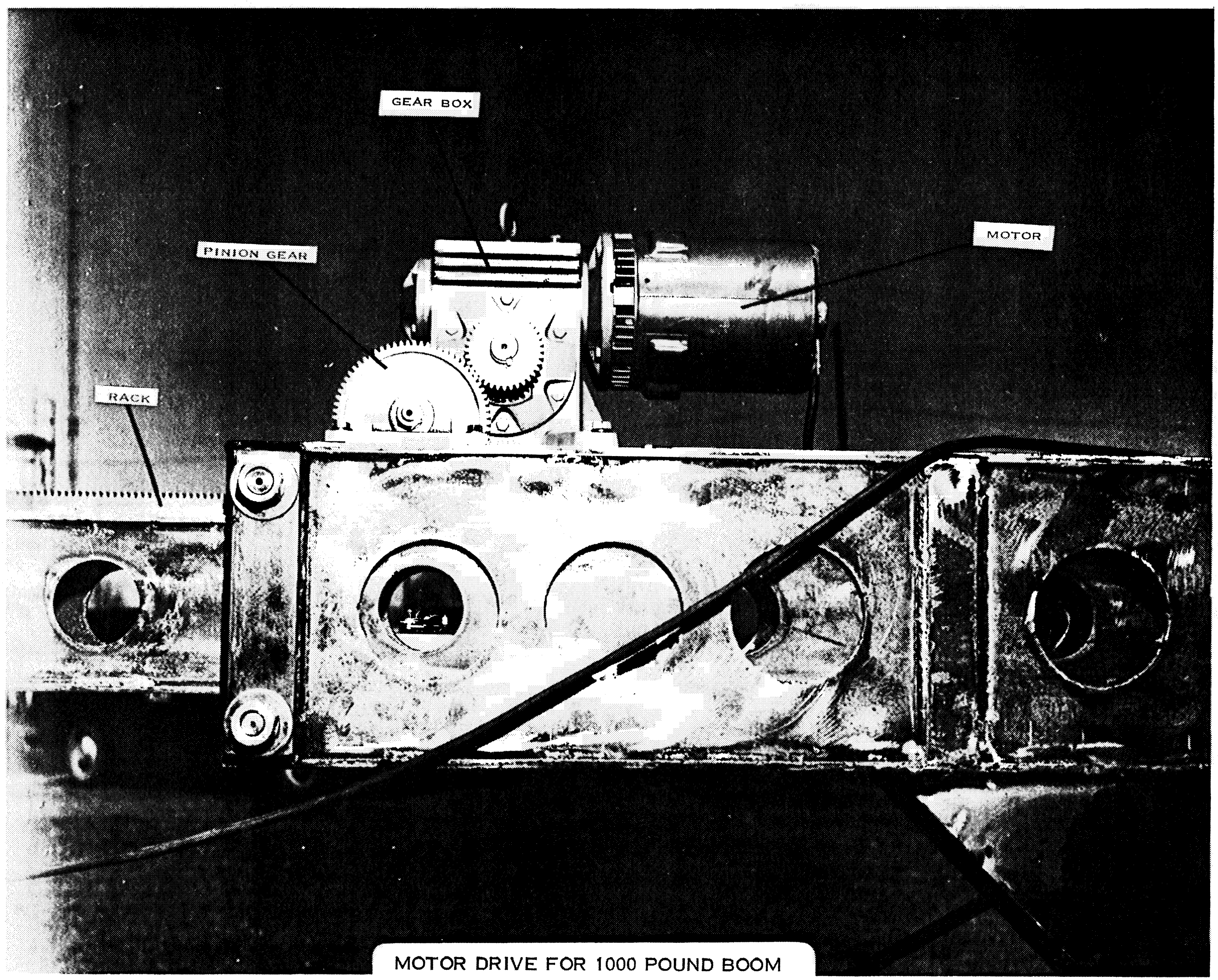
CRANE RIGGED WITH 200 POUND CAPACITY MOBILE BOOM

FIGURE II-16

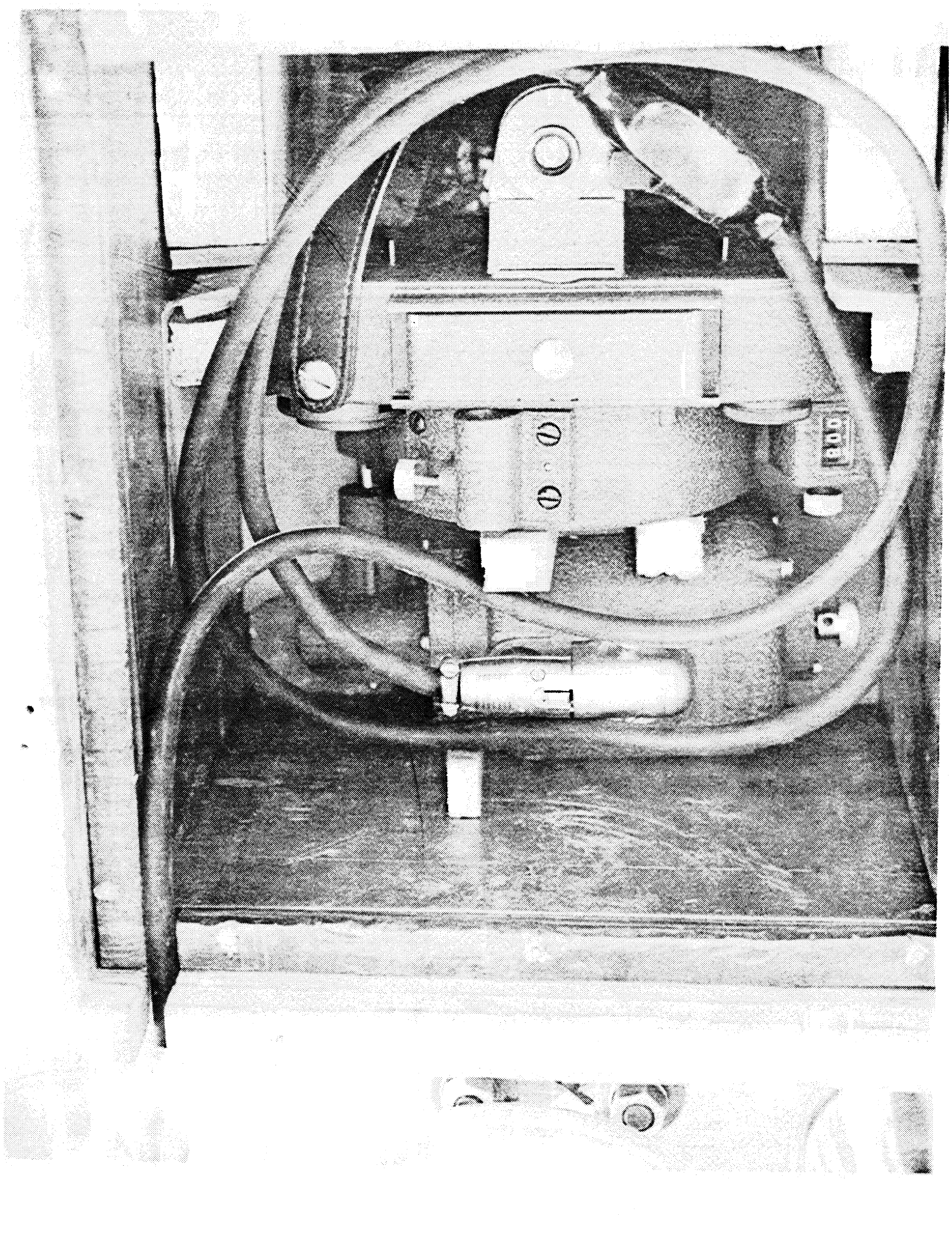


CRANE RIGGED WITH 1000 POUND CAPACITY MOBILE BOOM

FIGURE II-17



MOTOR DRIVE FOR 1000 POUND BOOM
FIGURE II-18



MOTOR DRIVE MOVIE CAMERA IN SHIELDED BOX
FIGURE II-19

weight of box and camera was approximately 190 pounds. The light and camera motor control switches were located in the crane shielded control station. Power cabling to the lights and camera was placed inside the travelling boom. The shielded box was mounted on a bracket welded to the end of the travelling boom. A drop light used for viewing in the reactor vessel was manipulated by the operator by cables supported on the boom by pulleys (Figure II-20).

Television viewing of the reactor internals required a camera capable of withstanding high gamma radiation, and which could penetrate the six inch control rod ports in the reactor vessel head. Additional requirements included long cable runs, and shock and weather resistant equipment.

The camera was a KinTel 1986C that had been modified by KinTel. The modification consisted mainly in the removal of the vidicon and focus control from the original assembly and placing it into an aluminum tube approximately five inches in diameter and 14 inches in lenght (Figure II-21). The tube had a fused quartz lens cover and the vidicon had a special fused quartz face. The camera was operated with a Wallensak one inch wide angle lens. The camera assembly was waterproof and was connected to the preamp with approximately 60 feet of multiconductor, highly flexible, cable. Fitting of the camera was accomplished by manipulation of two cables.

For use with the special camera, a 729 line KinTel camera control unit Model 1988 DCU and two video monitors model 1988-14R were procured. This system combination gave good pictures resolution, and photographing the monitor gave a more detailed picture. The two monitors connected in parallel were used by the operator for control of operation and for observation and photography respectively.

Difficulties experienced with the equipment included slippage of the vidicon caused by vibration and moisture shorting the cable connectors which were not designed for outdoor operation. An accumulated exposure of more than 10,000 roentgens resulted in no observable radiation effects upon the equipment.

3. Water Level Probe

Determination of water level in the reactor tank was approached in two phases:

Water level above the reactor core structure
Water level in and below the reactor core structure

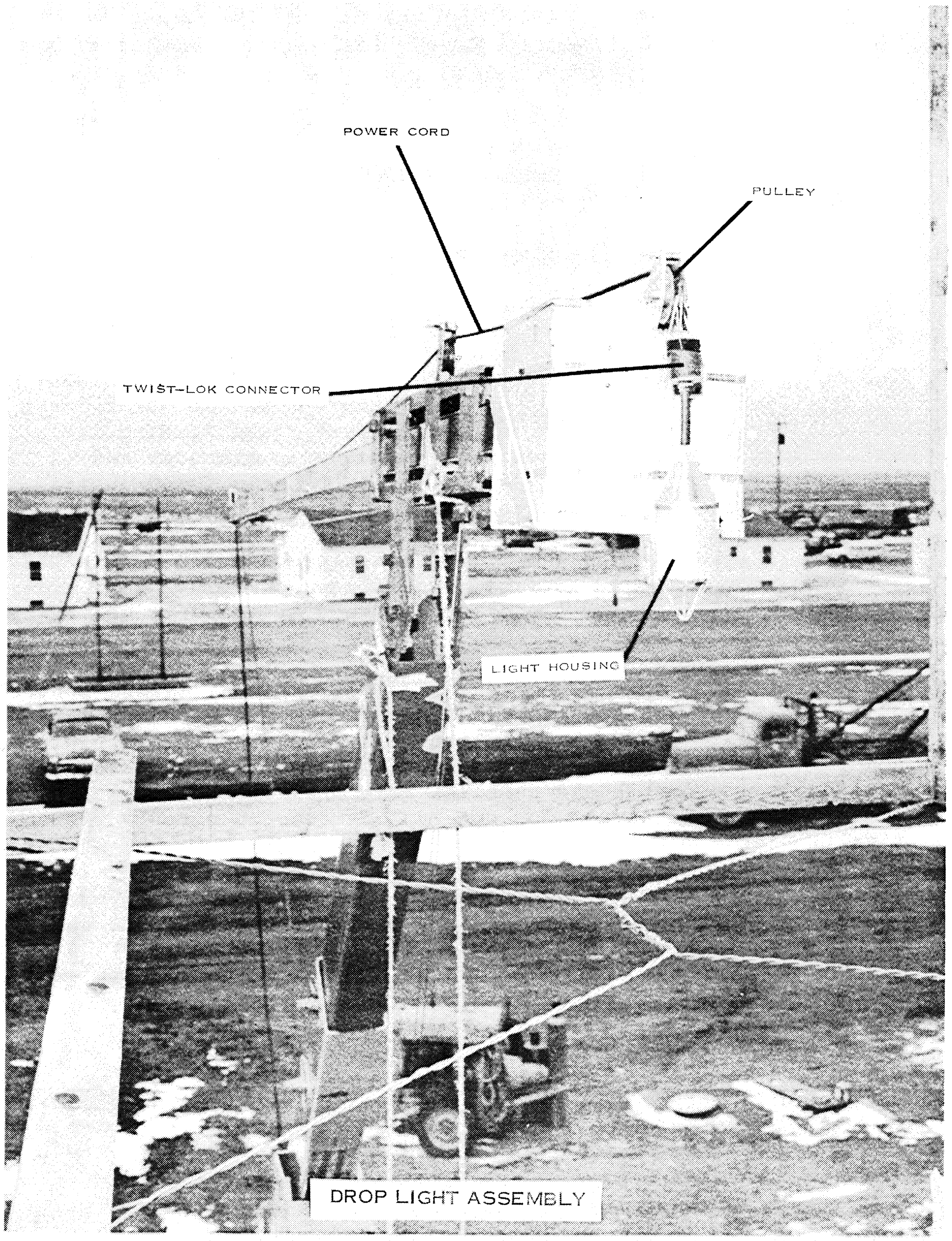

POWER CORD
PULLEY
TWIST-LOK CONNECTOR
LIGHT HOUSING
DROP LIGHT ASSEMBLY

FIGURE II-20

SPECIAL BARREL MOUNTED TELEVISION CAMERA

FIGURE II-21

A detector was required which would be capable of withstanding high gamma fields suitable for remote operation and satisfactory for positive indicating.

The first water level probe to the top of the core was made with an Ultrasonic Water Level Detector. When this probe indicated no apparent water level above the core, the development of a water sensitive probe small enough in diameter to penetrate the core structure was required.

a. Description of Ultrasonic Water Level Detector

The water level detection device used above the core was an ultrasonic liquid level probe manufactured by Powertron Ultrasonic Corporation of Garden City, New York. This probe uses the magnetostrictive properties of nickel to provide a sensitive element that vibrates at an ultrasonic frequency (40 kc/sec.) when exposed to air. As long as the sensitive element was not dampened the probe would continue to vibrate ultrasonically (Figure II-22). The instant the sensitive probe is immersed in a liquid the ultrasonic oscillation stops and is indicated by a light signal.

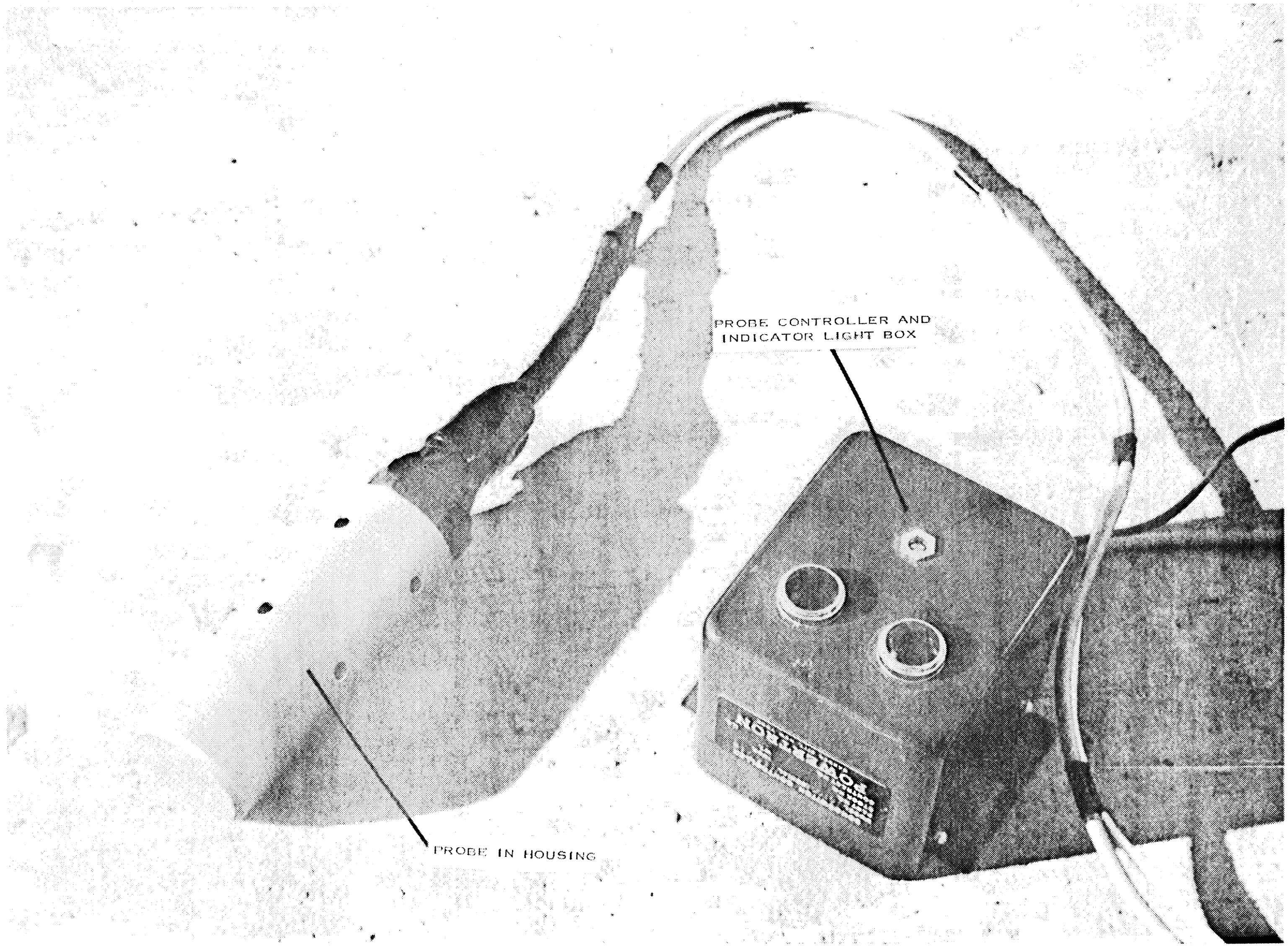
A housing was made to encase the ultrasonic probe. The housing served to protect the probe and to collect a water sample of approximately 50 cc's. (Figure II-22). A piece of blotter paper was taped to the bottom of the probe housing to permit indication in case that the water level was of insufficient height to reach the probe.

The controller unit was mounted behind the protective lead shield, and was powered by 115 volts AC. The connecting cable between probe and controller was strung through pulleys on the crane, and was used to support the weight of the probe.

b. Description of Chemical Water Level Probe

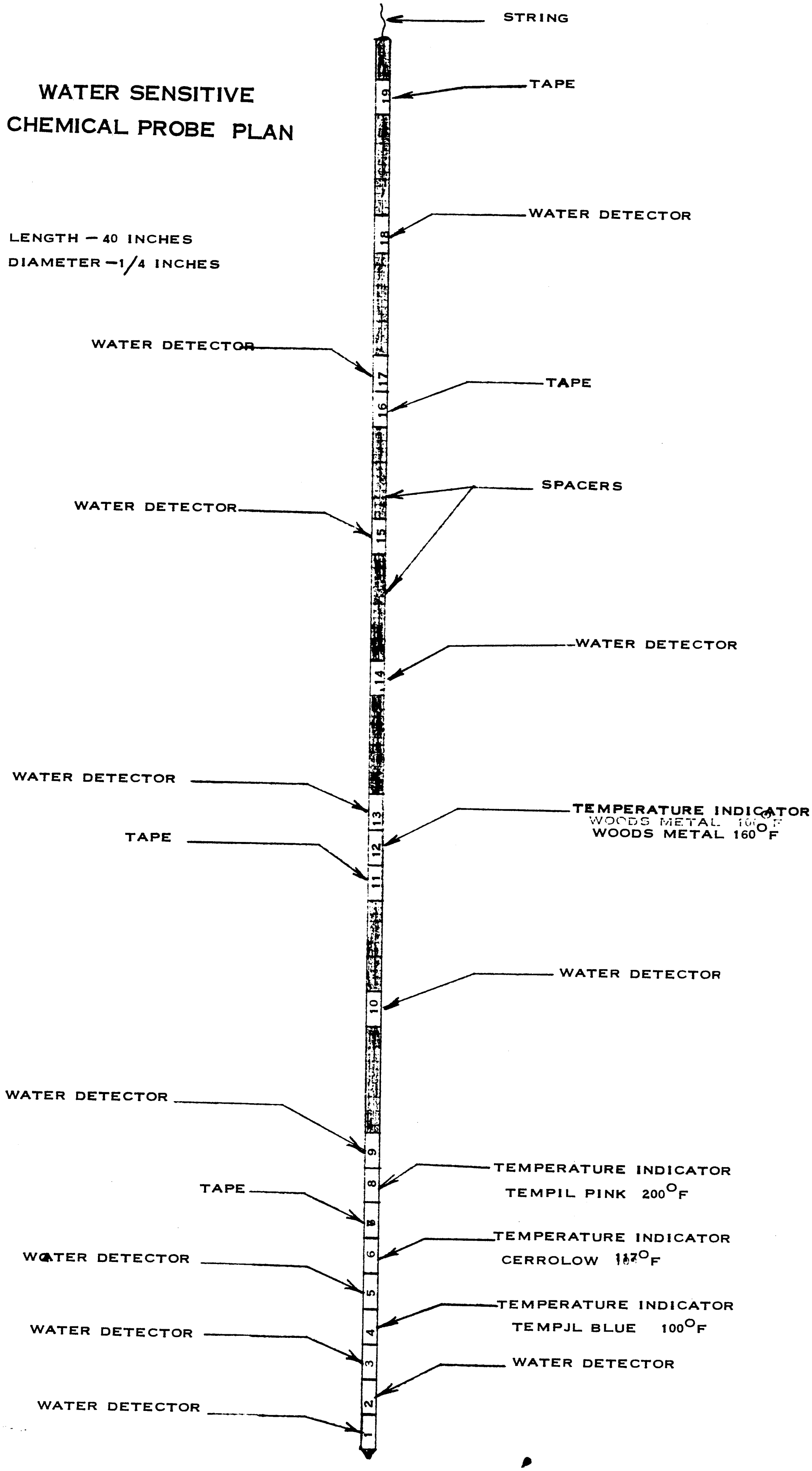
The chemical water probe consisted of 42 segments covered with Nylaflow tubing (Figure II-23). Each segment is 1 inch long and consists of a piece of one-quarter inch diameter Nylaflow tubing which has four radially drilled holes, each 0.025 inches in diameter. Stainless steel plugs are inserted into the tubing. These plugs are held together by a stainless steel rod, threaded into the plugs. Eastman 910 adhesive was used to attach the Nylaflow tubing to the plugs. The bottom piece of the probe was pointed to facilitate its entry into the reactor core while the top piece is designed to accommodate the support cable.

Chemically pure filter pulp was inserted into the segments along with a single $KMnO_4$ crystal (Figure II-24). One of the segments contains only the filter pulp in order to obtain a sample if water was encountered in the reactor vessel while another one had no holes in order to check the effect of radiation only on the segments.



ULTRASONIC PROBE AND HOUSING FOR WATER DETECTION

FIGURE II-22


STRING
WATER SENSITIVE
CHEMICAL PROBE PLAN
TAPE
WATER DETECTOR
LENGTH — 40 INCHES
DIAMETER — 1/4 INCHES
WATER DETECTOR
TAPE
SPACERS
WATER DETECTOR
WATER DETECTOR
WATER DETECTOR
TEMPERATURE INDICATOR
WOODS METAL 160°F
TAPE
WATER DETECTOR
WATER DETECTOR
TEMPERATURE INDICATOR
TEMPIL PINK 200°F
TAPE
TEMPERATURE INDICATOR
WATER DETECTOR
CERROLOW 117°F
TEMPERATURE INDICATOR
WATER DETECTOR
TEMPJL BLUE 100°F
WATER DETECTOR
WATER DETECTOR
19
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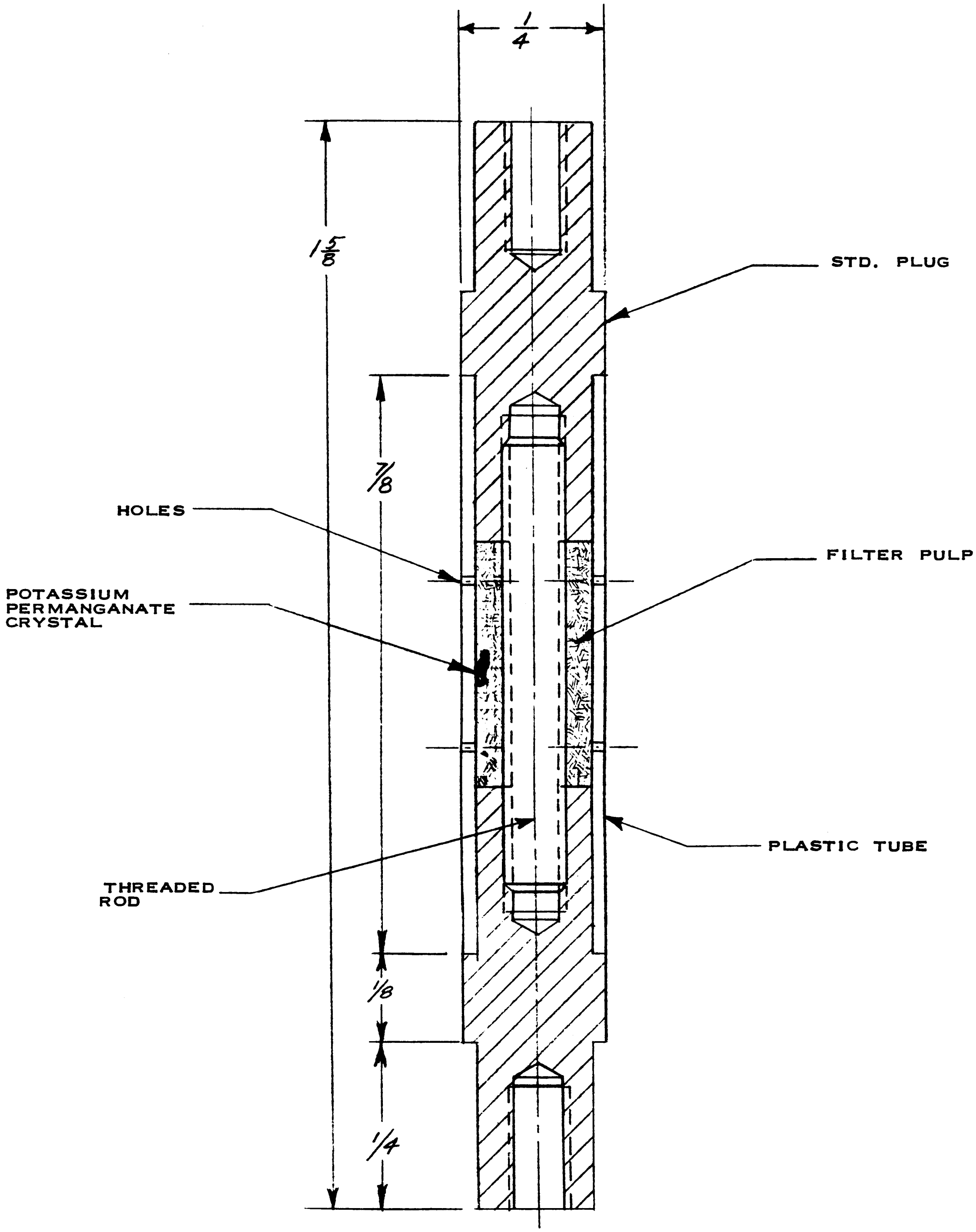
1

FIGURE II-23



WATER DETECTOR SEGMENT

FIGURE II-24

Water entering the small holes in the Nylaflow tubing would dissolve the $KMnO_4$ and color the filter pulp. The holes were too small to permit entry of steam or vapor, but allowed water to enter so that complete indication occurred in about 2 minutes.

Five of the segments of the water probe contained temperature detecting materials (Figure II-25). The temperature detectors used low melting point materials to compress a spring until the materials were heated beyond their melting points. As the materials were heated to their melting points, the springs would expand to fill the entire volume of the capsule. The materials chosen with respective melting points were:

(1) Tempil Blue - 100 ^{o}F
(2) Cerrolow - 117^{o}F
(3) Paraffin - 128 ^{o}F
(4) Woods Metal - 160 ^{o}F
(5) Tempil Pink - 200 ^{o}F

4. Miniature Camera Assembly

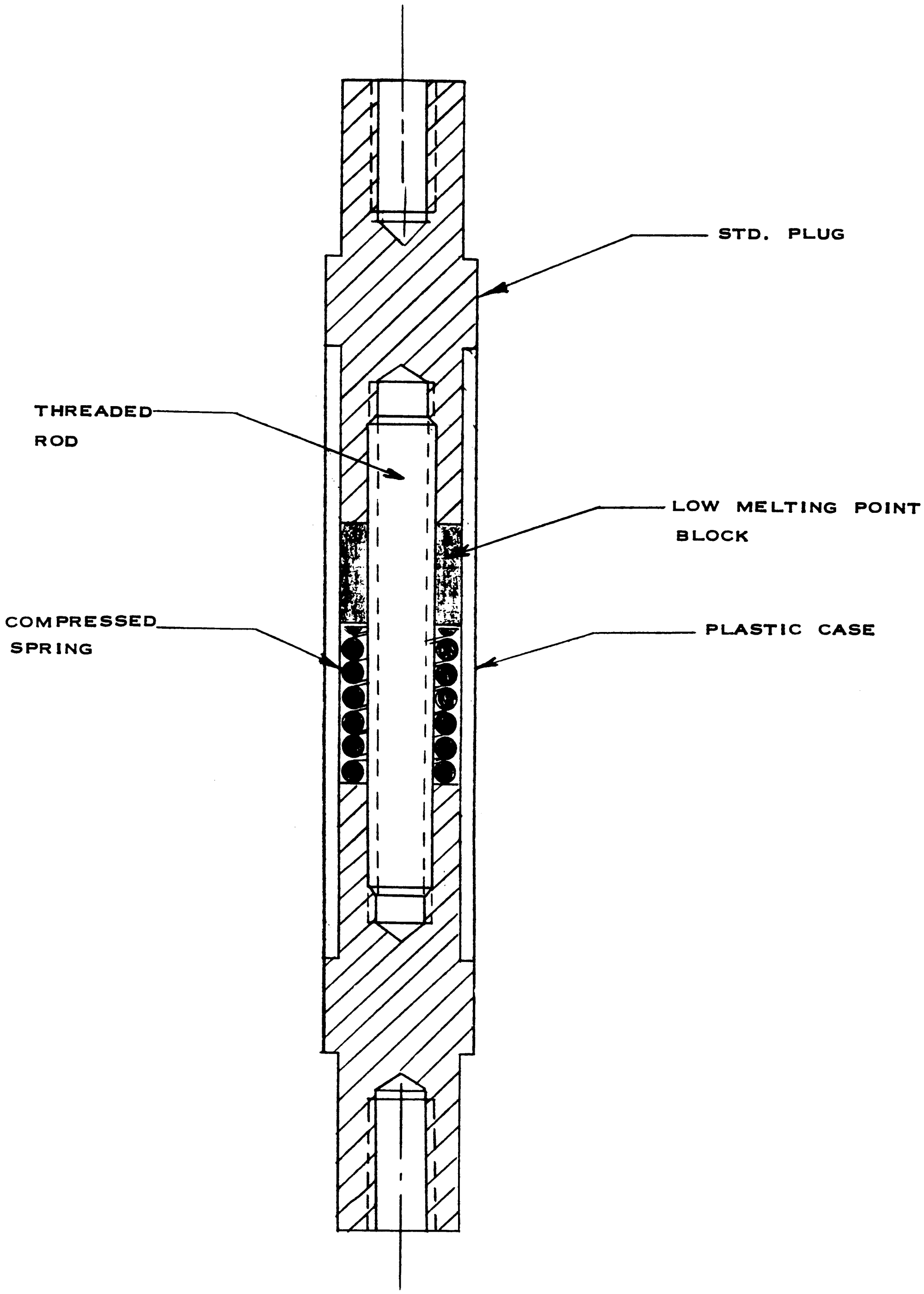
A standard Minox camera (Figure II-26) was adapted for use in a high radiation field and for remote operation. The camera is mounted in a stainless steel case with a minimum of 0.75 inch of lead shielding (Figure II-27). Three lights are mounted on the front end of the case. The entire assembly was suspended from the coaxial power cable. The camera shutter is cocked and the film advanced by a solenoid mounted above the camera. The shutter is opened and closed by a second solenoid mounted off to the side of the camera. The camera is mounted facing a 45 ^{o} front silvered mirror so that the camera and film are not directly exposed to the radioactive objects being photographed. The camera uses 9 millimeter film in a 50 exposure cartridge. A fine grain high radiation resistant documentary film was used.

The camera shutter was set for time exposures due to the slow film speed and low lighting level. The range of exposure times used was one to eight seconds. A block was clamped to the power cable above the camera assembly to serve as a suspension point to prevent any camera movement during the time exposures. The camera operator timed the exposures with a stopwatch.

A tilting device was used which consisted of 2 cables of different lengths fastened to the camera housing and supported from a ring clamped to the power cable.

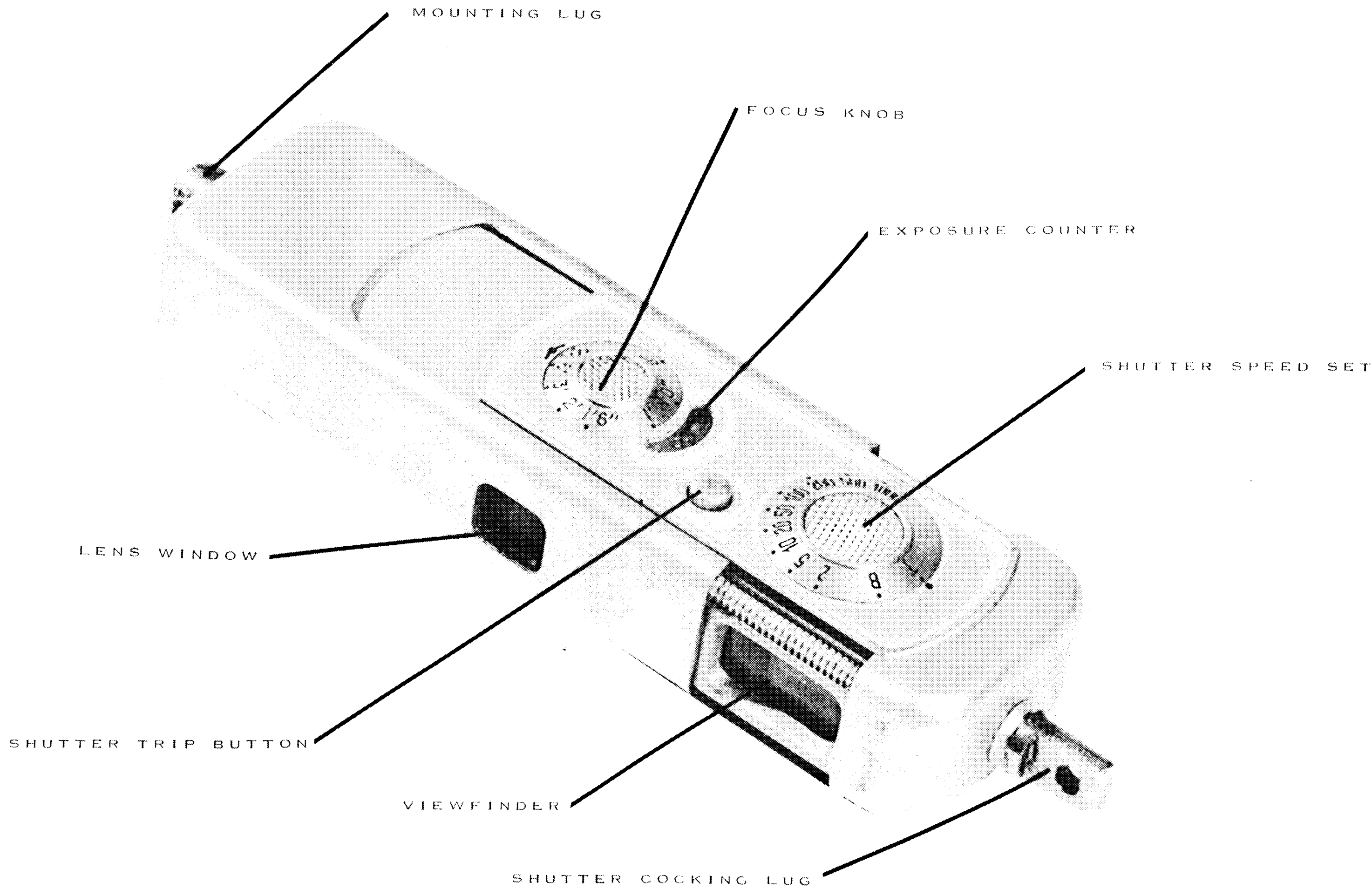
The camera assembly is supported by the power cable which was run along the horizontal crane boom over pulleys. The cable terminates in a control box behind the crane shielding.

The camera control box contains power supplies for the lights and camera solenoid switches. Switches are provided for AC power, lights, cocking solenoid, and shutter solenoid. A counter records the exposure number.



TEMPERATURE SENSING SEGMENT

FIGURE II-25



MINOX CAMERA

FIGURE II-26

MINOX CAMERA AND SHIELDING ASSEMBLY

FIGURE II-27

The ammeter indicates light current, and will show the operator when a light burns out.

5. Reactor Dry Sample Removal System

The equipment used in obtaining a dry sample from the SL-1 core surfaces was a modified hand vacuum cleaner (Figure II-28).

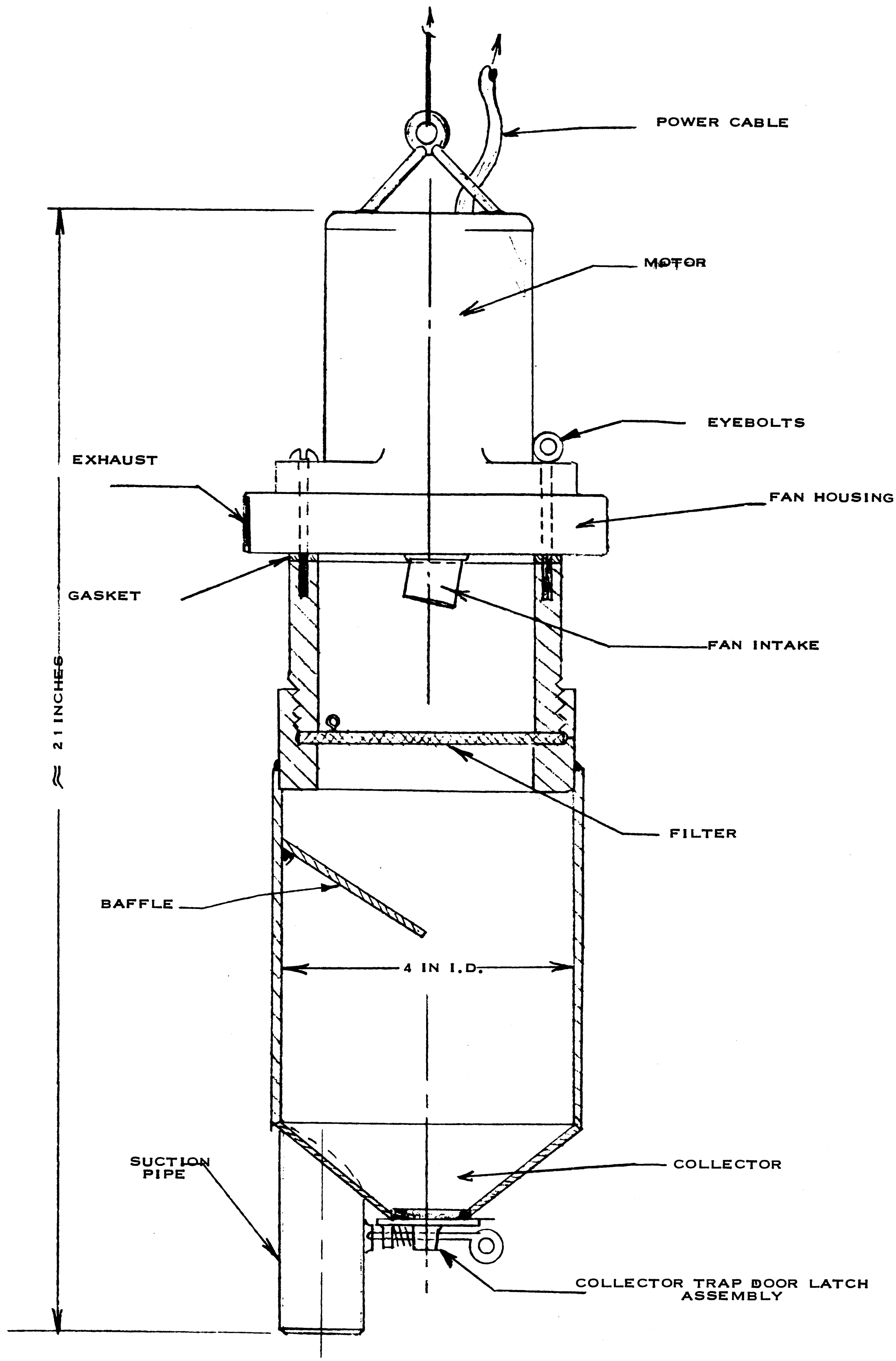
Modification consisted of machining away the exhaust connection and removing the fan inlet connection. The inlet section was replaced with a collection chamber and filter assembly fabricated from stainless steel. The collection chamber was fabricated in two sections and threaded together. A filter was removed from an assault mask cannister M-11 and was installed between the threaded sections to enable collecting of very fine dust particles.

The upper section was bolted through the impeller housing to the motor housing. The lower section had an eccentrically located suction pipe welded through the conical lower end. Centrally located in the lower end was a latch operated trap door for removing samples.

The handle was removed from the vacuum cleaner and replaced with a bracket attached to the end of the motor housing. This bracket was used as an anchor point for the electrical cable; the electrical cable also served as the supporting member for the vacuum pick-up assembly.

The vacuum pick-up assembly is maneuvered by means of pulleys attached to a traveling boom on an Austin-Western crane.

During operation, particles are picked up through the suction nozzle and pulled into the collection chamber. The heavier entrained particles then drop out and fall to the bottom of the collection chamber. The lighter particles remain in the air stream and impinge on the filter where they remain until the vacuum is turned off.



VACUUM SAMPLING ASSEMBLY

FIGURE II-28

D. CHRONOLOGY OF SIGNIFICANT DEACTIVATION EVENTS

Date	Event
1/17/61	A radiation survey was performed in the SL-1 yard area and buildings, except the reactor tank.
1/17/61	Gamma and neutron monitor systems were installed under and around the Reactor Building to provide an emergency warning system in the area.
1/23/61	An unsuccessful attempt was made to view the vessel head with closed circuit television.
1/23/61	A movie film was taken of the reactor operating floor and head area. The film provided the first pictorial records of the full reactor vessel head since the incident.
1/26/61	An unsuccessful entry was made to take television pictures of the core.
2/2/61	A neutron detection chamber was installed in the SL-1 beam hole.
2/7/61	An unsuccessful attempt was made to view the reactor vessel internals and core with a closed circuit television system.
2/22/61	A motion picture film was taken of the core through all open vessel head nozzles. This viewing provided the first pictorial information of the condition of the reactor core.
2/28/61	A sonic water level probe was dropped eleven feet four below the top of No. 8 flange with no evidence of reactor water indicated.
3/16/61	A television camera was dropped into the reactor vessel for viewing of the vessel and core structure.
3/17/61	The television camera entry of 3/16/61 was repeated to obtain movie film coverage of the TV monitor during the core viewing.
3/29/61	A chemical probe was lowered one foot six inches below the active core with no evidence of water. A thermocouple probe was dropped to the top of the core during the same entry and a maximum temperature of 98 $^{\circ}$F was recorded.

Date	Event
4/15/61	A chemical probe was lowered 2 feet 6 inches below the active core with no evidence of water. A miniature camera picture recorded the probe penetration of the core structure through No. 8 control rod shroud.
4/20/61	A vacuum sample collector unit was dropped through No. 8 nozzle and operated for seven minutes. A 1.4 mg sample of metal fuel alloy and 8.7 mg sample of boric acid crystals were collected.
5/3/61	A movie film and radiation survey were made of the SL-1 operating floor and ceiling.
5/11/61	A miniature still camera was dropped through No. 8 nozzle and 39 pictures were taken of the core.
5/17/61	A shield plug was removed from the reactor head and a television camera was dropped through No. 4 nozzle for viewing of the core, and 400 feet of movie film was taken.
5/19/61	A miniature still camera was dropped through No. 4 nozzle and 31 pictures were taken of the core.

E. INFORMATION OBTAINED TO ESTABLISH THE SL-1 SHUTDOWN CONDITION

Concern about the possibility of another nuclear excursion occurring and the need to know the conditions existing inside the reactor vessel, to enable poisoning of the core, necessitated that a number of entries be performed. As each entry into the reactor building occurred, additional knowledge was obtained until sufficient information about the condition of the core was established.

1. Viewing of the Reactor Operating Floor and Head Region

Shortly after the excursion a photographer entered the reactor operating floor and obtained six photographs of the vessel head and adjacent areas. Photographs taken later in EP-RO-8 provided overhead views of the reactor vessel head area and a partial inventory of the reactor components located in this region (Figures II-29 and 30). The position of three of the control rods was estimated following observation of the control rod mechanism racks protruding from the vessel head. Figure II-31 presents a short analysis of the rod extension positions. Water seen in recesses in the shield blocks and water marks on the ceiling indicated that some quantity of water had been expelled from the reactor vessel.

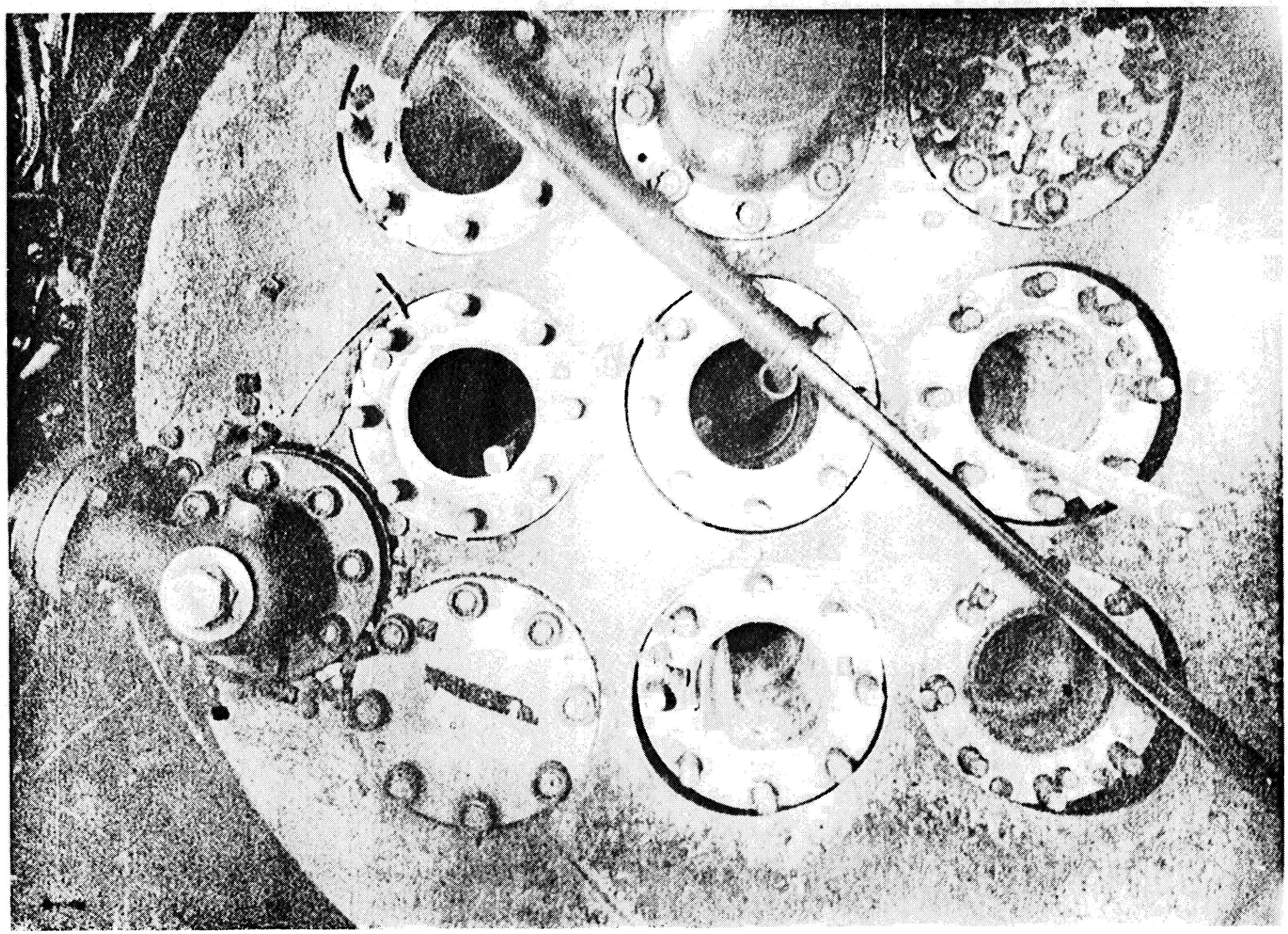
2. Viewing of the Reactor Vessel Internals and Core

The first significant information about the condition of the reactor core was obtained by dropping a television camera and light through the reactor vessel head (Nozzle No. 8). Photographs taken of the television monitor revealed substantial core damage as well as some information on location of control rods and fuel assemblies (Figures II-32 and 33), a photographic composite of many core views was prepared (Figure II-34) and an analysis by special photographic interpretation methods was completed (8). The analysis is presented below:

<u>Position No. 1</u> The shrouds have been folded flat and crushed against the thermal shield. The control rod appears to be in a completely down position. (The Figure 9 appearing on the rod in the 16-17 March photos is an illusion made by the connection between the ball section and the upper, narrow end of the control rod). The upper spray ring obscures a portion of the No. 1 area.

<u>Position No. 2</u> Area is partially obscured by Control Rod No. 9. Several fuel elements are identifiable.

<u>Position No. 3</u> The shrouds have been bent and twisted and moved toward the thermal shield. The control rod is in a down position and has moved about 8 inches toward the downcomer. A gaping hole remains at the former position of the control rod and the shroud. A cross-stanchion lies across the No. 3 area tilted at a 45 ^{o} angle from the vessel wall, downward toward No. 9 position.



VIEW OF SL-1 REACTOR VESSEL HEAD AFTER INCIDENT

FIGURE II-29

VIEW OF SL-1 REACTOR VESSEL HEAD AFTER INCIDENT

FIGURE II-30

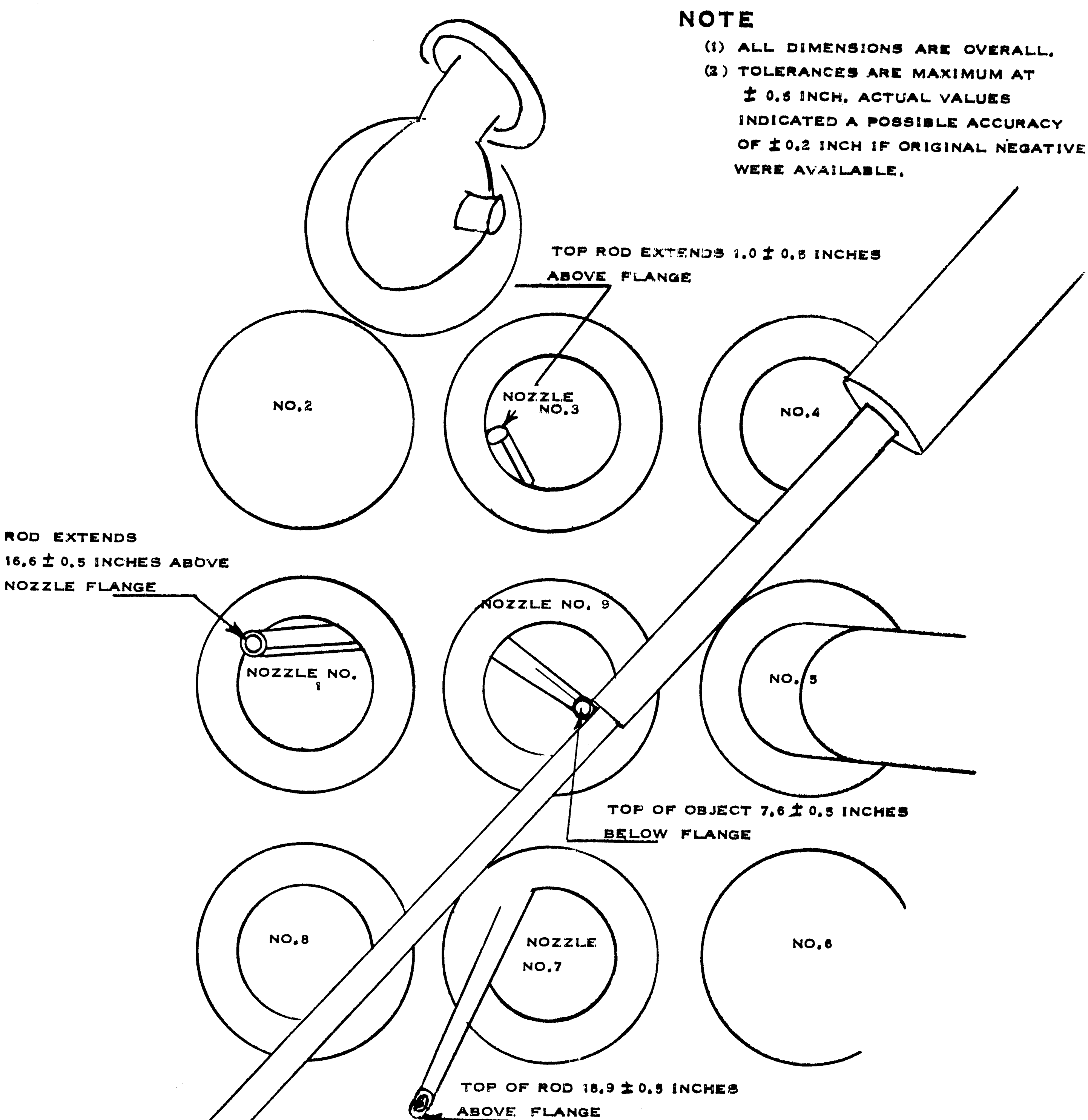
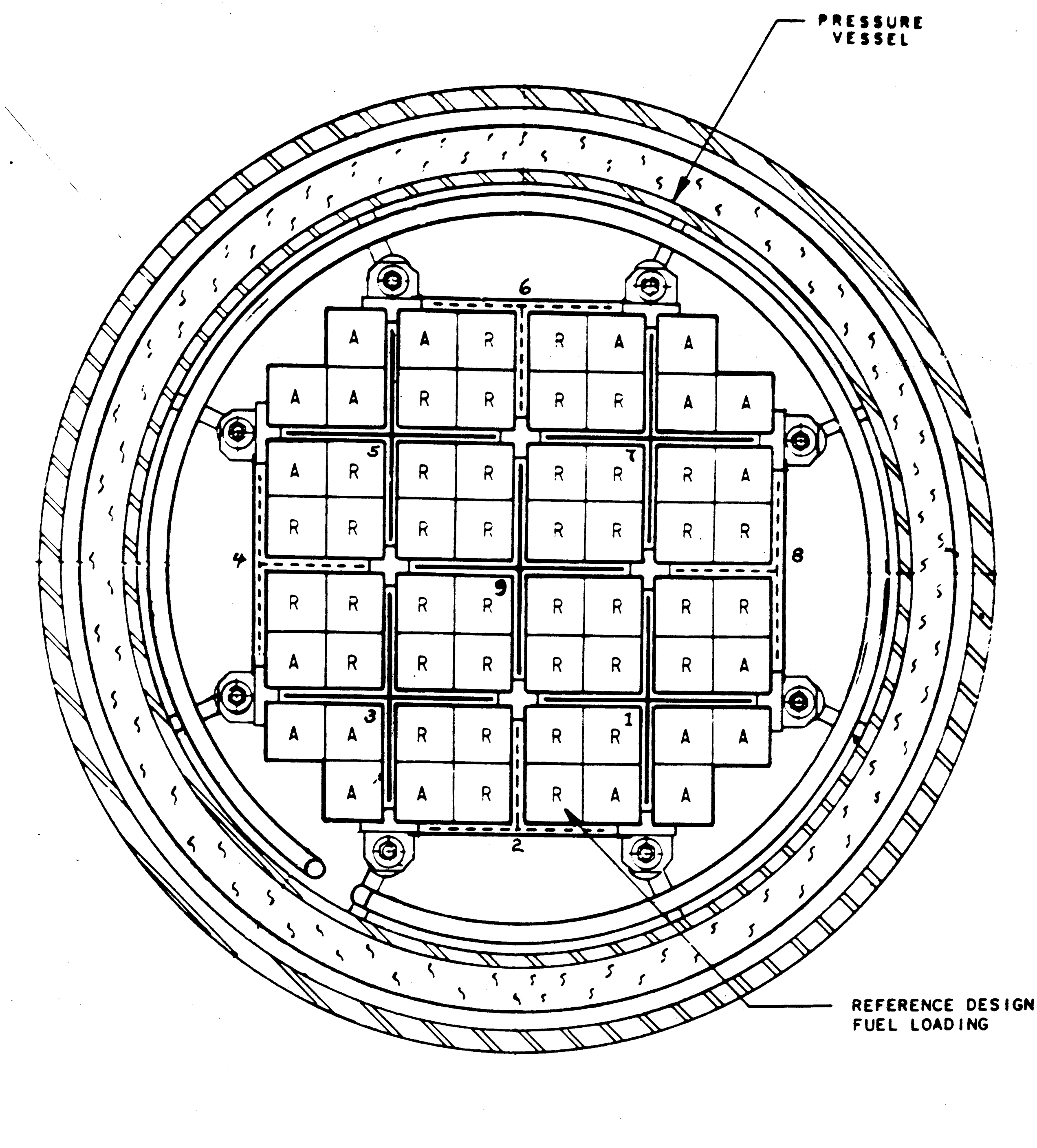


PHOTO ANALYSIS OF SL-1 CONTROL ROD EXTENSION POSITIONS AFTER INCIDENT

FIGURE 11-31


PRESSURE
VESSEL
REFERENCE DESIGN
FUEL LOADING

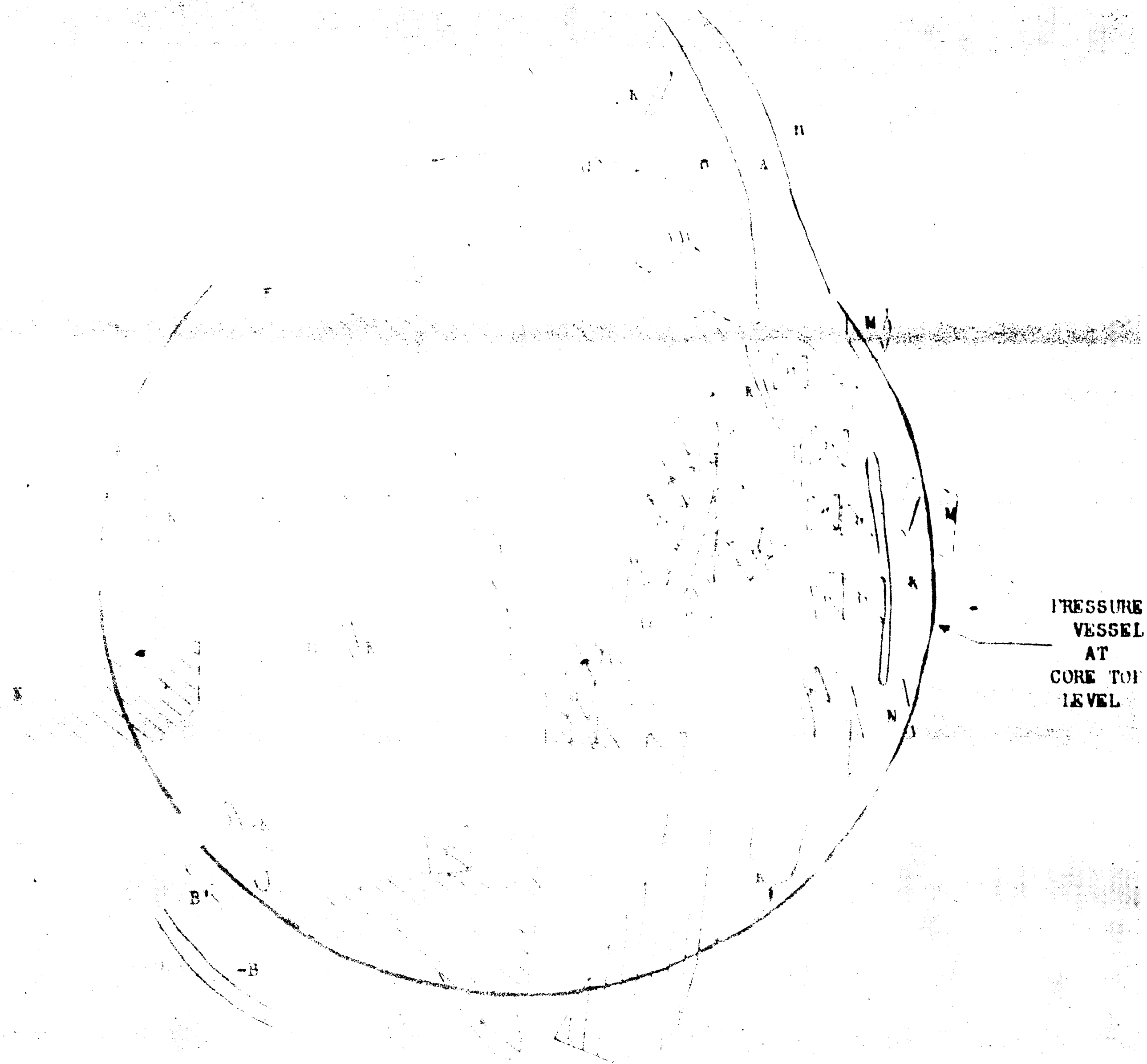
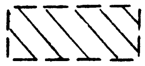

PRESSURE VESSEL AT CORE TOP LEVEL

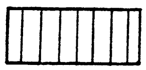
PHOTO-ANALYSIS OF VESSEL INTERIOR
(REPRINTED FROM USNPIC REPORT N-PZII P.6)

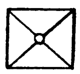
Fig. II-34

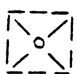
LEGEND

SYMBOLS

 - Areas Obscured by #9 Control Rod

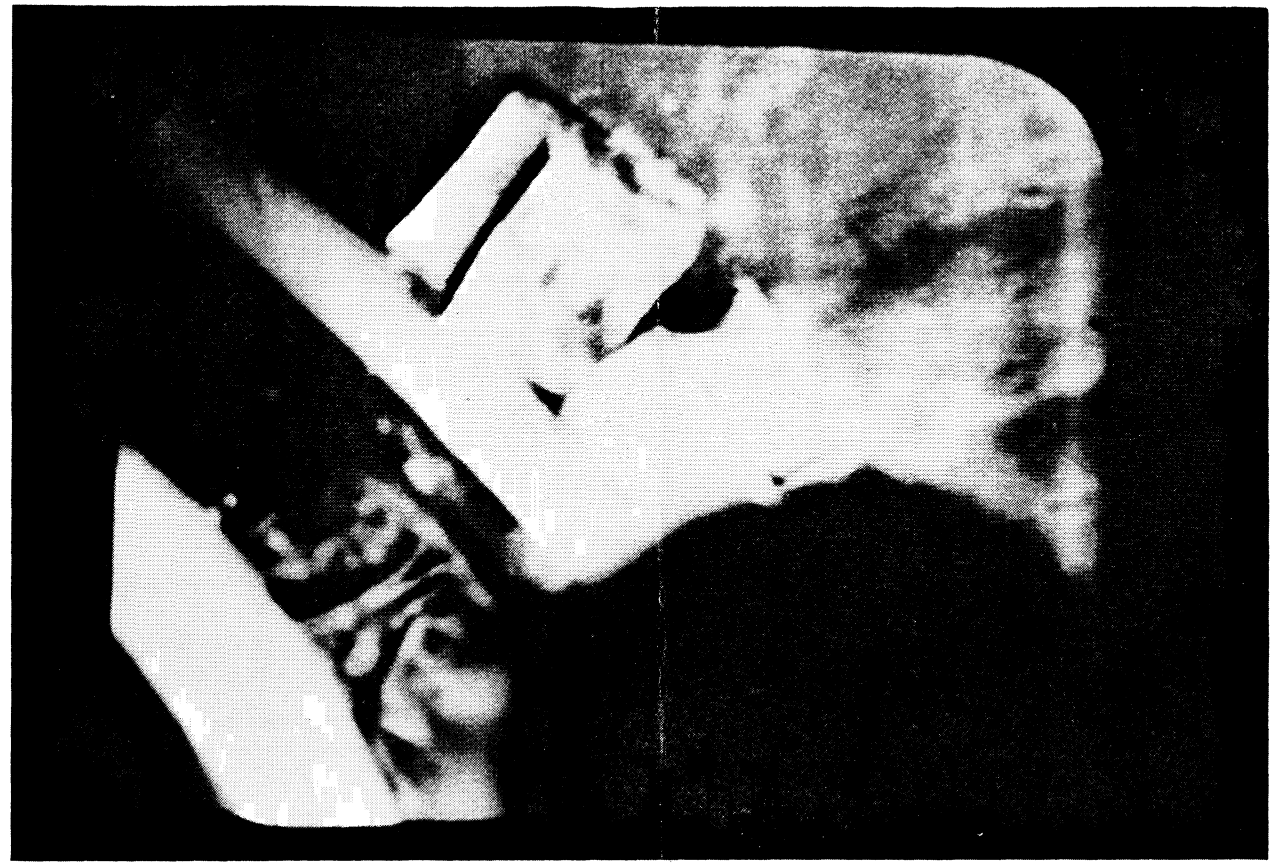
 - Area Obscured by Upper Spray Ring

 - Fuel Element Boxes and Spare Boxes

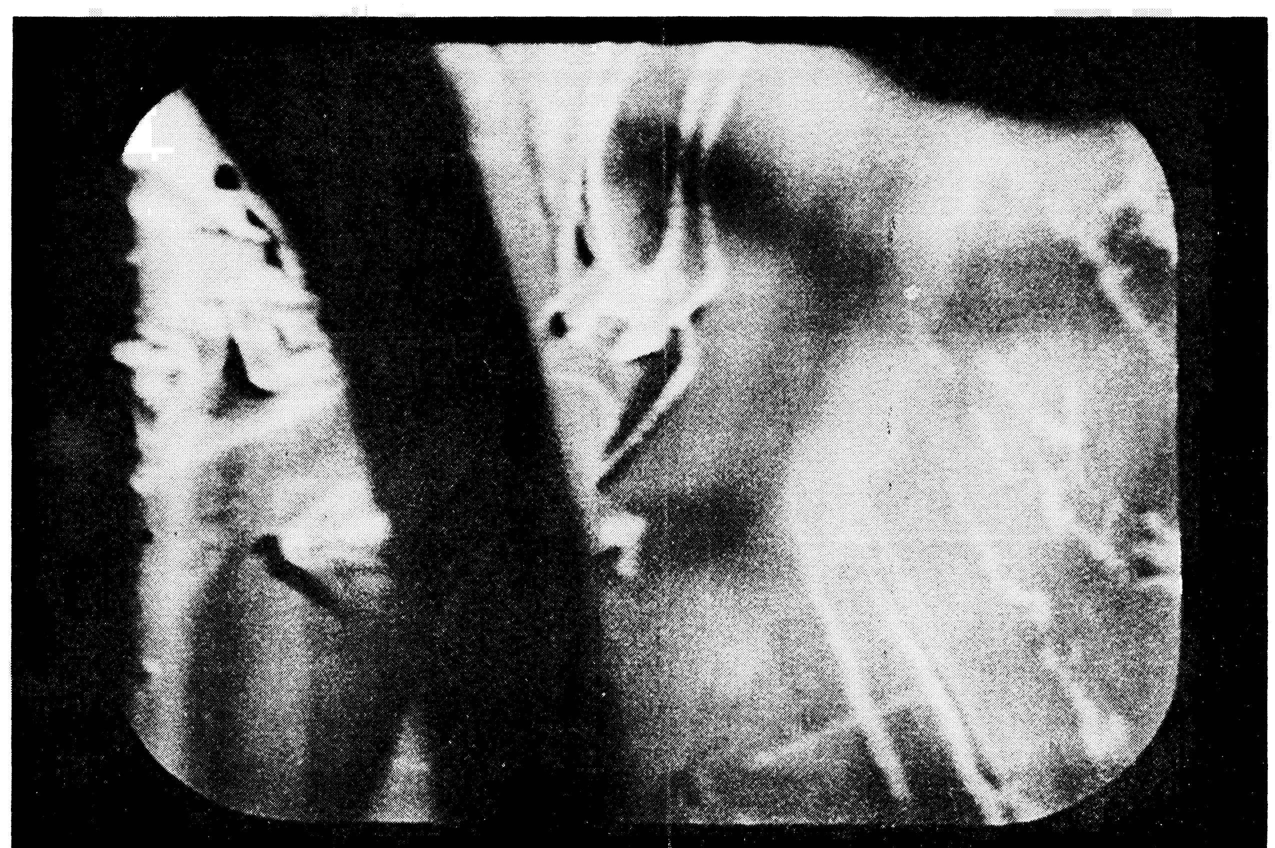
 - Possible Additional Boxes

ANNOTATIONS

A	- Upper Spray Ring
B	- Lower Spray Ring
B'	- Lower Spray Ring Bracket
C	- Filler Pipe - Lower Spray Ring
D	- Spare 1" Pipe
E	- Purification Water Inlet
F	- #5 Rod Extension
G	- #7 Rod Extension
H	- Probable Cross-Stanchion from #9 Shroud Area
J	- Possible Cross-Stanchion from #9 Shroud Area
K	- Shrouds
L	- Possible Shroud
M	- Probable Tops of Fuel Boxes
N	- Unidentified



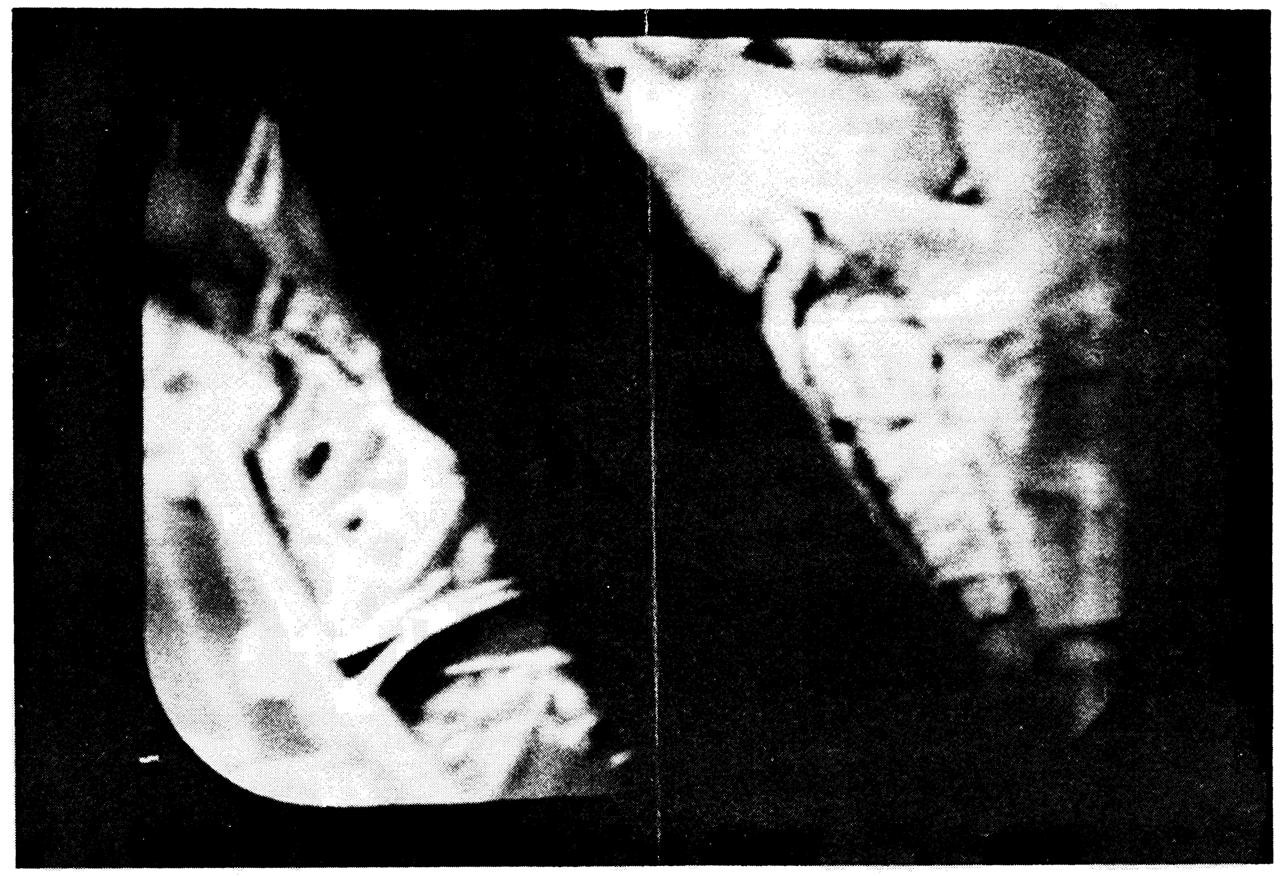
Spray ring with two full element end boxes resting on top. Ring is out about 3 inches from wall. Shroud No. 8 visible in center. Portion of the other spray ring visible in corner.



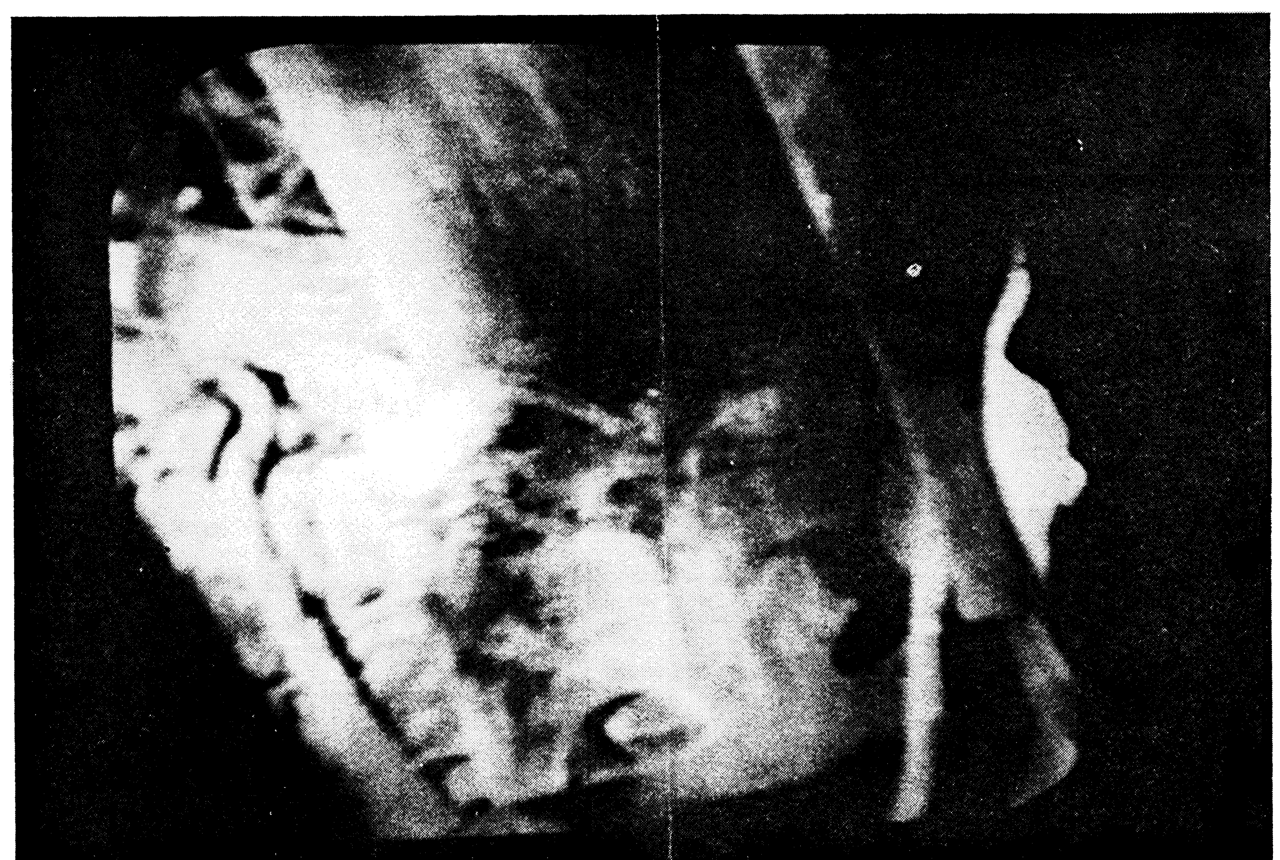
Shroud No. 1 with control rod and rack in place. Spray ring in foreground. Square objects may be tops of fuel elements.

OVERHEAD VIEWS OF DAMAGED CORE

FIGURE II-32



Shroud No. 8 with two fuel elements in place toward shroud No. 1 which is barely visible. in corner. Holddown box on top of fuel elements. The downcomer area is visible behind shroud No. 8. Spray ring in center of picture. Rod No. 9 shroud with step on left. Possibly two fuel elements visible between No. 9 shroud and spray ring.



The shroud of No. 9 with two holes and step section, possibly two fuel elements.

OVERHEAD VIEWS OF DAMAGED CORE

FIGURE II-33

Position No. 4 The shroud, part of which is visible, has been smashed against the pipes at the vessel wall. The upper end of the $1\frac{1}{4}$ inch filler pipe to the lower spray ring has been ripped loose and twisted toward No. 3. Most of the area lies in the shadow of Control Rod No. 9.

Position No. 5 The rod extension appears to be in full down position. Part of Control Rod No. 9 is crushed against it and obscures the shroud. It has been moved toward the downcomer, but how much is not determinable.

Position No. 6 Part of the shroud is visible. Most of area is hidden by Control Rod No. 9, No. 7 rod extension, and the upper and lower spray rings.

Position No. 7 The control rod is in the down position. The rod and shroud have been twisted and displaced toward the vessel wall about 6 - 8 inches. The rod extension and the rack have been bent or broken at the union joint. A probable fuel box top lies between the shroud and the vessel wall.

Additional views of reactor tank interior were obtained with a remotely operated Minox camera inserted in No. 8 and No. 4 nozzles. A composite view of the two core areas was constructed from the above views and is described below:

Nozzle No. 8 Composite (Figure II-35) - No water above the core was apparent. Shroud No. 8 was displaced outward toward the vessel wall assuming a curved shape. Distorted fuel plates are evident. Displaced and bent holddown boxes are visible. Upper and lower feedwater spray rings were dislodged.

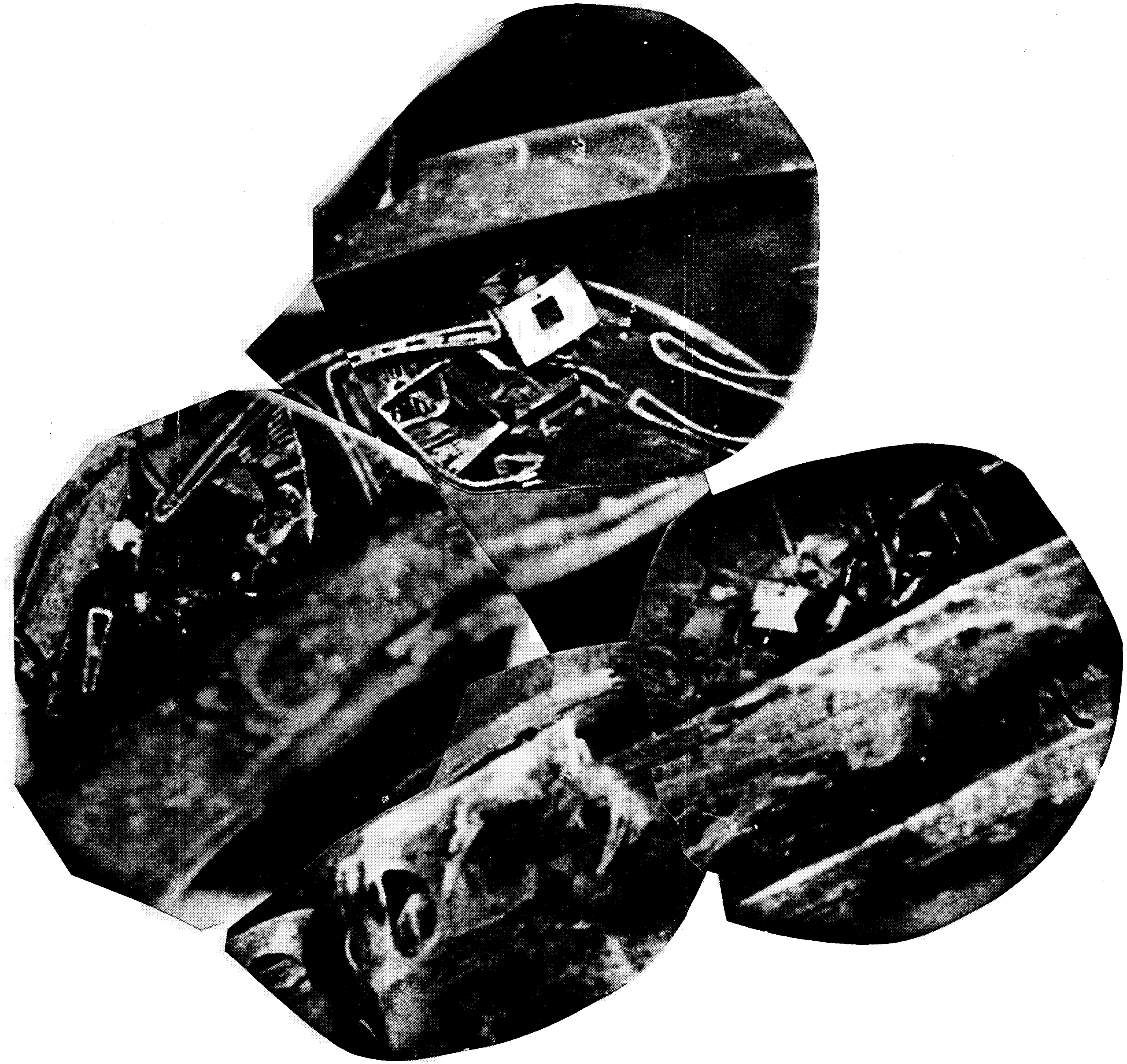
Nozzle No. 4 Composite (Figure II-36) - Core damage appears more severe in this section of the core as compared to view through Nozzle No. 8. Rod No. 4 with attached weight is visible. Steam baffle has been displaced from original position.

Conclusions from pictures taken to May 20, 1961, are summarized:

a. Control Rods No. 1, 3, 5, and 7 appear to be fully or partially inserted in core region. Rod No. 9 is fully out of the core and is resting on top of the core structure.

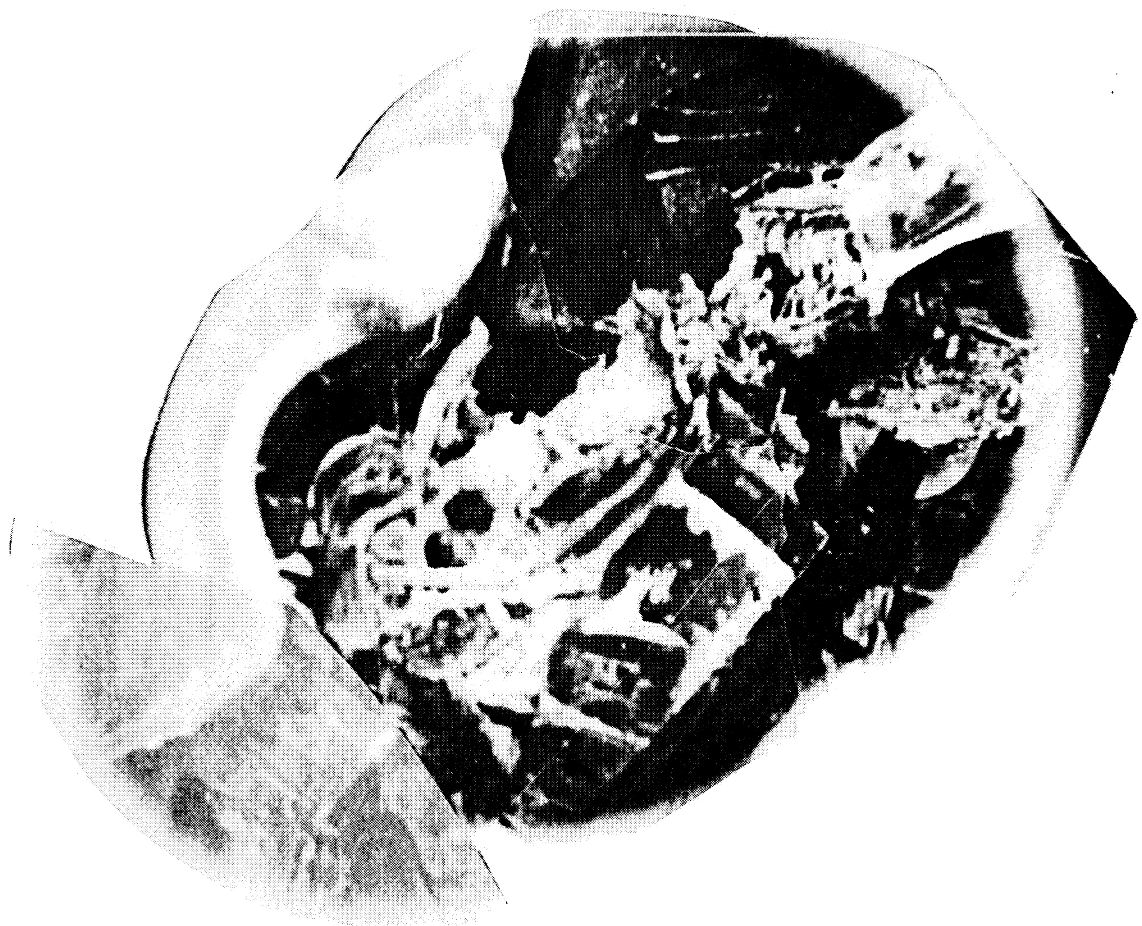
b. Fuel Elements - Approximately one-half of the fuel elements can be identified and these elements appear to be severely twisted, collapsed, and have moved outward from their original positions toward vessel walls.

c. Core - The core has been expanded such that the nine inch wide downcomer region is essentially filled. No major holes can be



COMPOSITE VIEW OF DAMAGED CORE AROUND CONTROL ROD POSITION NO. 8 WITH MINOX CAMERA

FIGURE II-35



COMPOSITE VIEW OF DAMAGED CORE AROUND CONTROL ROD POSITION NO.4 WITH MINOX CAMERA

FIGURE II-36

observed in the core regions. However, No. 9 rod and shroud obscure the center of the core from view.

d. Shrouds - All control rod shrouds appear to be partly collapsed, twisted away from the core center, and are dislocated toward the vessel walls. Rod No. 9 shroud has been partially blown out of the core and is engaged with the lower part of Rod No. 9.

e. Spray Rings - The lower spray ring has been blown to a position several feet above the core structure. The ring is bent out of round, twisted, and partly collapsed. The upper spray ring has been bent out of round and has dropped below its original elevation in the vessel.

f. Vessel Wall - No damage to the vessel wall is apparent.

g. Thermal Shield - No damage to the thermal shield is apparent.

3. Reactor Temperatures Recorded Inside Reactor Vessel

Temperature data were taken inside the reactor vessel with a thermocouple probe in entry EP-RO-15. A temperature of 90°F was indicated under the vessel head. At a position on top of the core structure, a reading of 98°F was observed.

4. Reactor Water Level

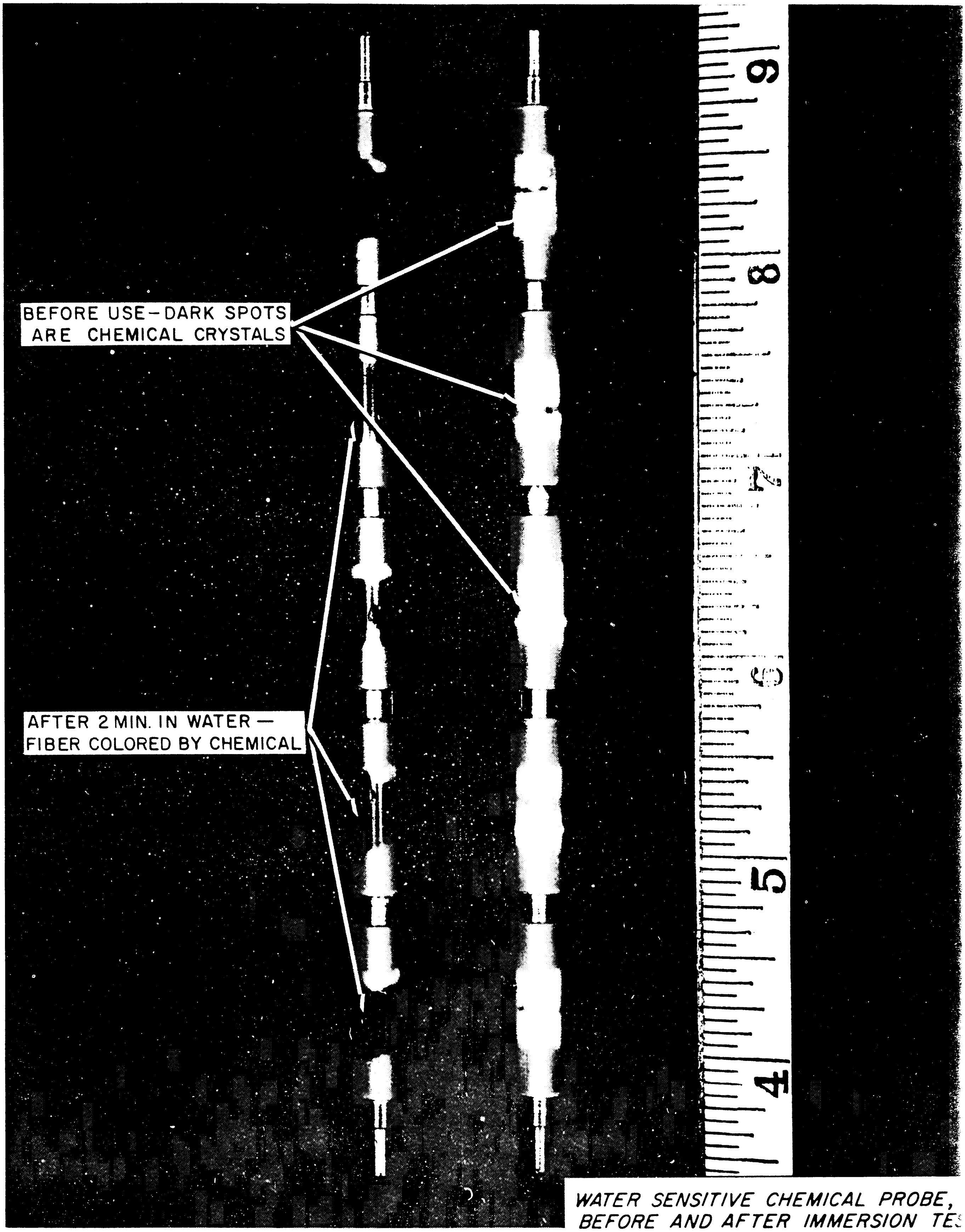
To establish the water level in the reactor vessel after the incident, visual, sonic, and chemical detectors were used. The visual method relied upon observation of reflections of a light on the surface of the water. This method was used in entries EP-RO-9 and EP-RO-14. No reflections were observed. Locating water level was then attempted with a sonic probe (EP-RO-10). This probe was lowered to the upper surface of the core and established that the level was below the top of the core structure.

The final probe for water level was made with a small diameter water sensitive chemical probe (Figure II-37).

In entry EP-RO-16, the probe penetrated the core structure to the bottom of the reactor vessel with no evidence of water. Penetration of the core by the probe through control rod shroud No. 8, was verified by a miniature camera photograph (Figure II-38).

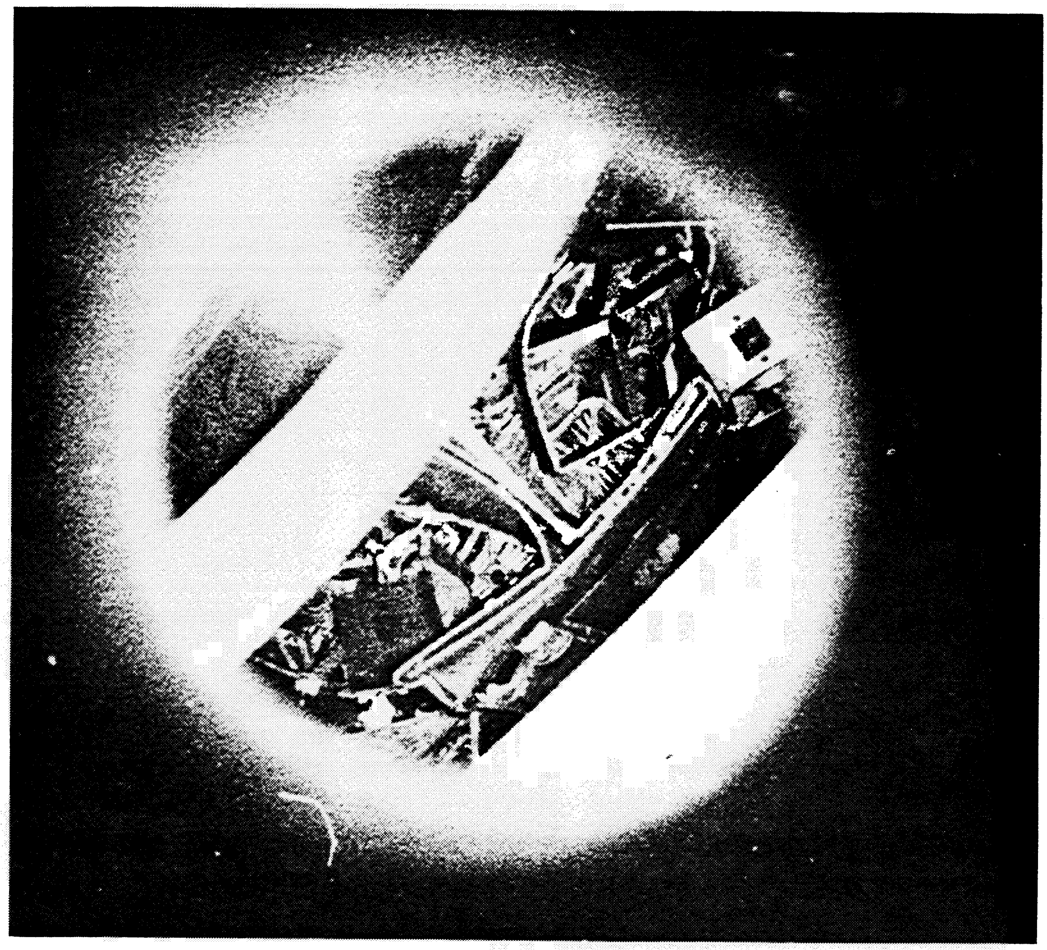
F. ADDITIONAL INFORMATION OBTAINED AFTER SHUTDOWN CONDITION WAS ESTABLISHED

Once it had been established that there was no water in the SL-1 reactor vessel, the objective of entries became that of obtaining information pertaining to the cause and extent of nuclear excursion and to perform those tasks which would lead to decontamination of the plant.



WATER SENSITIVE CHEMICAL PROBE, BEFORE AND AFTER IMMERSION TE

Fig. II–



PHOTOGRAPHIC EVIDENCE OF CHEMICAL PROBE PENETRATING CORE STRUCTURE THROUGH CONTROL ROD SHROUD NO.8.

FIGURE II-38

1. Photographing the Reactor Core

Photographs obtained of the reactor core by taking movies of the television monitor gave first indications of the reactor core mechanical condition. Minox pictures taken through vessel head nozzle No. 8 (Entry EP-RO-20) gave a clearer indication of the damage to the core. Information obtained at this entry is given below.

a. Thirty-nine photographs of the inside of the reactor vessel were obtained. These photographs indicate the condition of approximately 40% of the core. The photographs show in greater detail the destruction previously observed. (Television Entry EP-RO-14) i.e., the material appears to be moved in a general direction away from center, much debris is resting on top of the fuel assemblies, fuel plates are bent and distorted, and wires are laying across the top of the core (See Figure II-35).

Subsequent entries were performed in head nozzle No. 4, after the shield plug laying across the head was removed. The first entry into this nozzle was with the television camera (Entry EP-RO-21). The television camera was primarily lowered into the No. 4 nozzle to determine that is was clear to lower the miniature camera into the reactor vessel for more detailed photographs. The television views showed a greater degree of destruction than has been observed to the other side of the core viewed through nozzle No. 8. The TV camera showed, however, that the miniature camera could be lowered through the No. 4 head nozzle.

Because the television camera could not be traversed, views of the No. 9 control rod and blade were limited to looking straight down the nozzle hole from above the vessel head. These views indicate that in addition to the control rod connector there appears to be a steel shielding plug wedged into the hole.

Photos then taken through nozzle No. 4 with the shielded camera (EP-RO-22) confirmed the indications of core destruction. Forty photographs of the inside of the reactor vessel and over nozzle No. 9 were obtained. Review of the photographs indicate that the tilting arrangement for the camera did not function. For this reason, there are only three groups of photographs which show any differences in area covered. Review of these pictures shows in more detail the destruction of the core that was observed by viewing of the television monitor movies. Close scrutiny of a plate laying above the core indicates that it is very probably a piece of the steam baffle (See Figure II-36).

2. Samples Obtained from Reactor

A modified vacuum cleaner was lowered into the reactor vessel (Entry EP-RO-17). The vacuum sample collector unit was dropped into the SL-1 reactor vessel to four feet two inches below the No. 8 nozzle flange. Penetration below this level was not accomplished because of interference of the spray rings. The vacuum unit was operated for approximately seven minutes in the reactor vessel. A quantity of white crystalline material and some tiny pieces of metallic appearing substances were obtained. The samples were weighed, gross activity measured, photographed, and analyzed by emission spectroscopy, mass spectrometry, X-ray spectroscopy, pulse height scanning and fluoroscopic analysis for Uranium.

The results are summarized below:

a. Sample No. 1 - White Crystalline Material (See photomicrograph, Figure II-39)

This was found to be rather high purity boric acid, H_3BO_3, with some fission product contamination associated with it. Mass spectrometry showed the B^{10}, B^{11} abundance ratio to be natural (ratio of 4.06/1).

Its source is very likely the boric oxide in the head region, since with heat and hydration this converts to Boric Acid.

b. Sample No. 2a (See photomicrograph) (Figure II-40)

This is unquestionably a melted particle of fuel material, since the principle elements are those comprising the fuel alloy (U, Al, and Ni), and the 90% U^{235} content is in agreement with the SL-1 enrichment (91%).

c. Sample No.2b(See Figure II-41)

This is a piece of carbonaceous material.

d. Sample No. 3

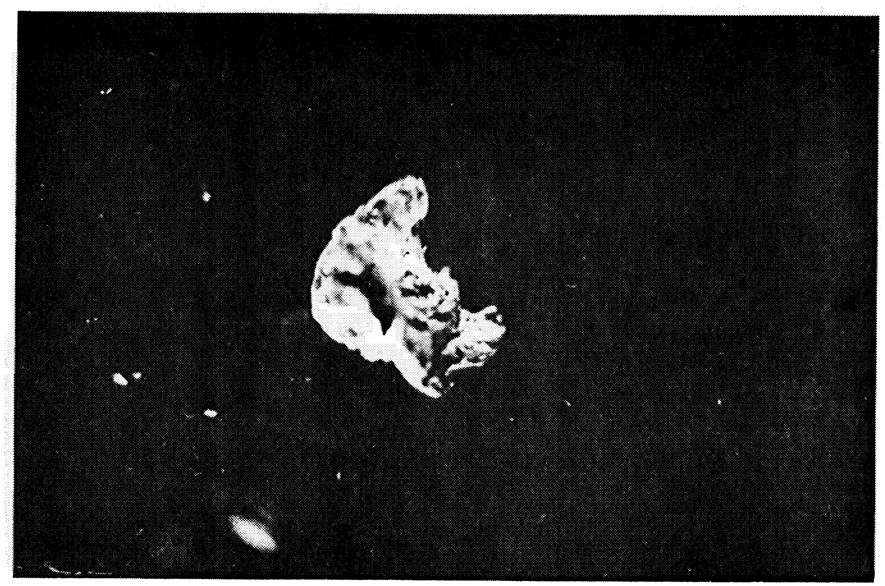
This is an extremely tiny particle of fuel material, similar to sample No. 2a.

3. Photographic Scanning of Ceiling of the Reactor Operating Room

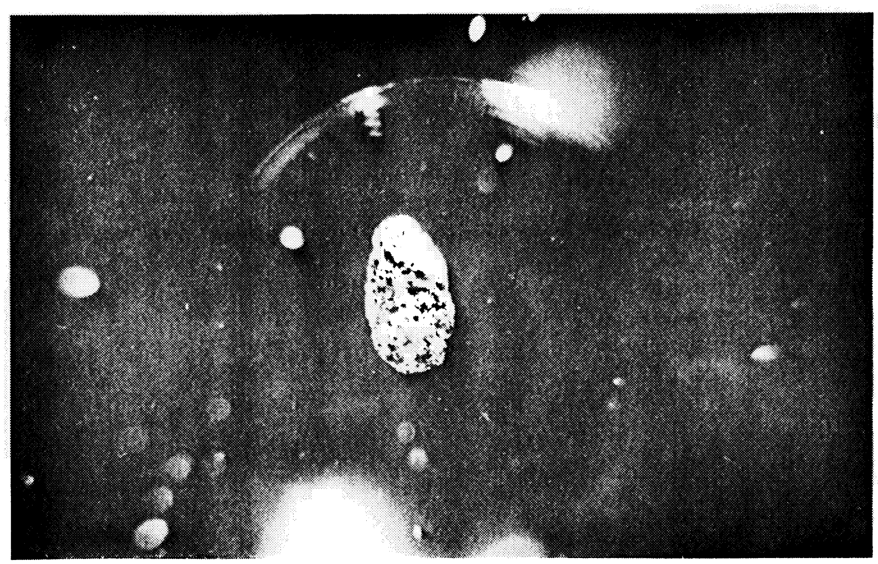
A sequence of movie film was taken of the ceiling over the reactor vessel region. The pictures (Figures II-42 and II-43) show damage done to support beams by shield plugs when ejected from the reactor head. Holes in the sheetmetal ceiling caused by two control rod drive plugs are evident. One shield plug may be seen still embedded in the ceiling (Figure II - 43). Some debris has accumulated on the ceiling support structure.

CRYSTALS OF BORIC ACID REMOVED FROM REACTOR VESSEL

FIGURE II-39



PARTICLE OF MELTED FUEL ALLOY
REMOVED FROM REACTOR VESSEL
FIGURE II-40

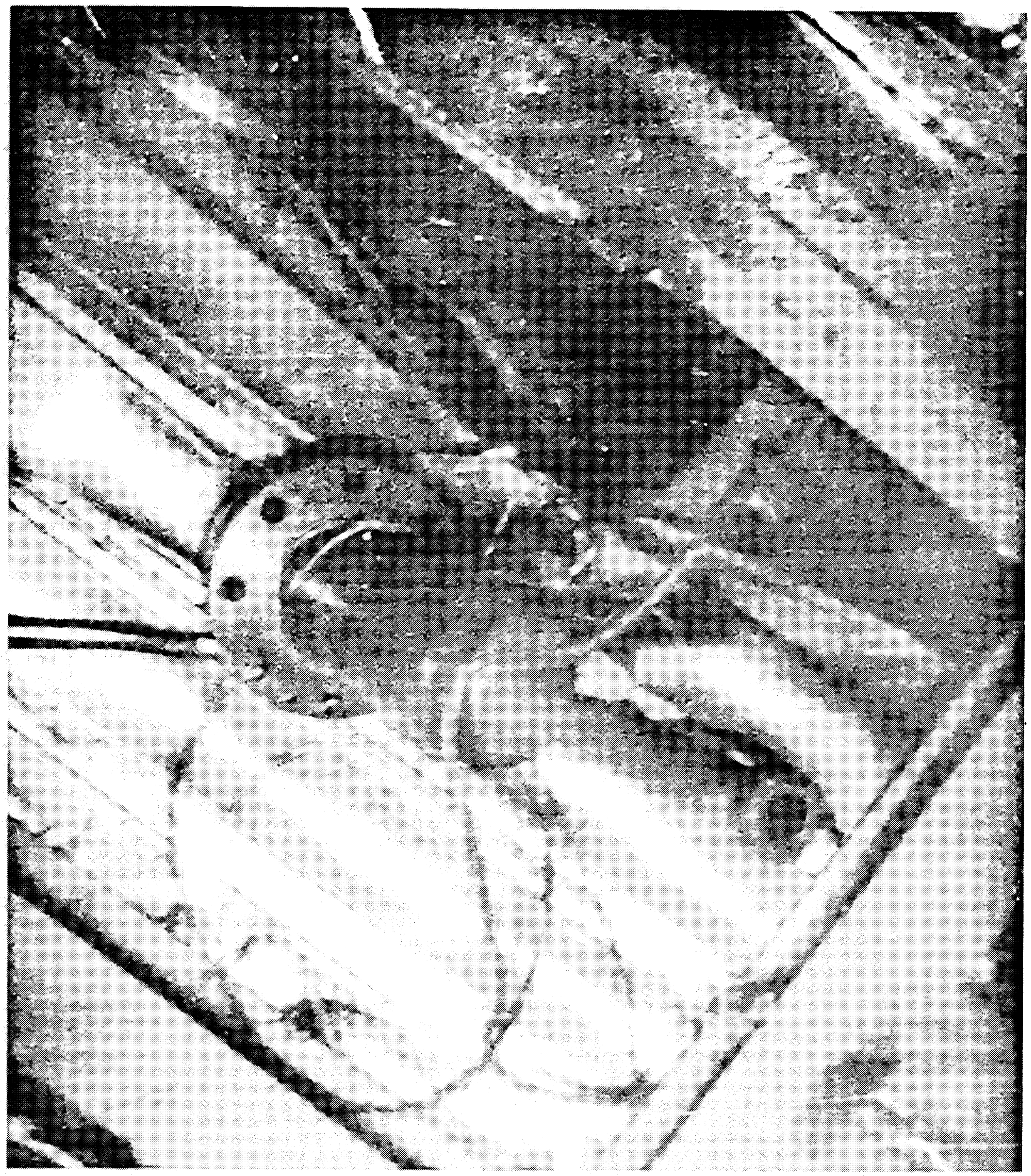


PARTICLE OF CARBONACEOUS MATERIAL
REMOVED FROM REACTOR VESSEL

FIGURE II-41

DAMAGE TO FAN FLOOR ABOVE REACTOR HEAD

FIGURE II-42



DAMAGE TO FAN FLOOR ABOVE REACTOR HEAD

FIGURE II-43

G. RADIATION SURVEY

1. Inside Reactor Building

Gamma and neutron radiation surveys were performed in the reactor vessel and in the reactor operating room at intervals during the five month period following the incident. The survey data were obtained generally as a secondary effort in entries having other objectives. Gamma and neutron detectors were attached to the equipment inserted into the building for photography, temperature measurement, water level determination, etc.

This section describes the instrumentation, outlines the procedures, and presents a summary of the measured results.

a. Instrumentation

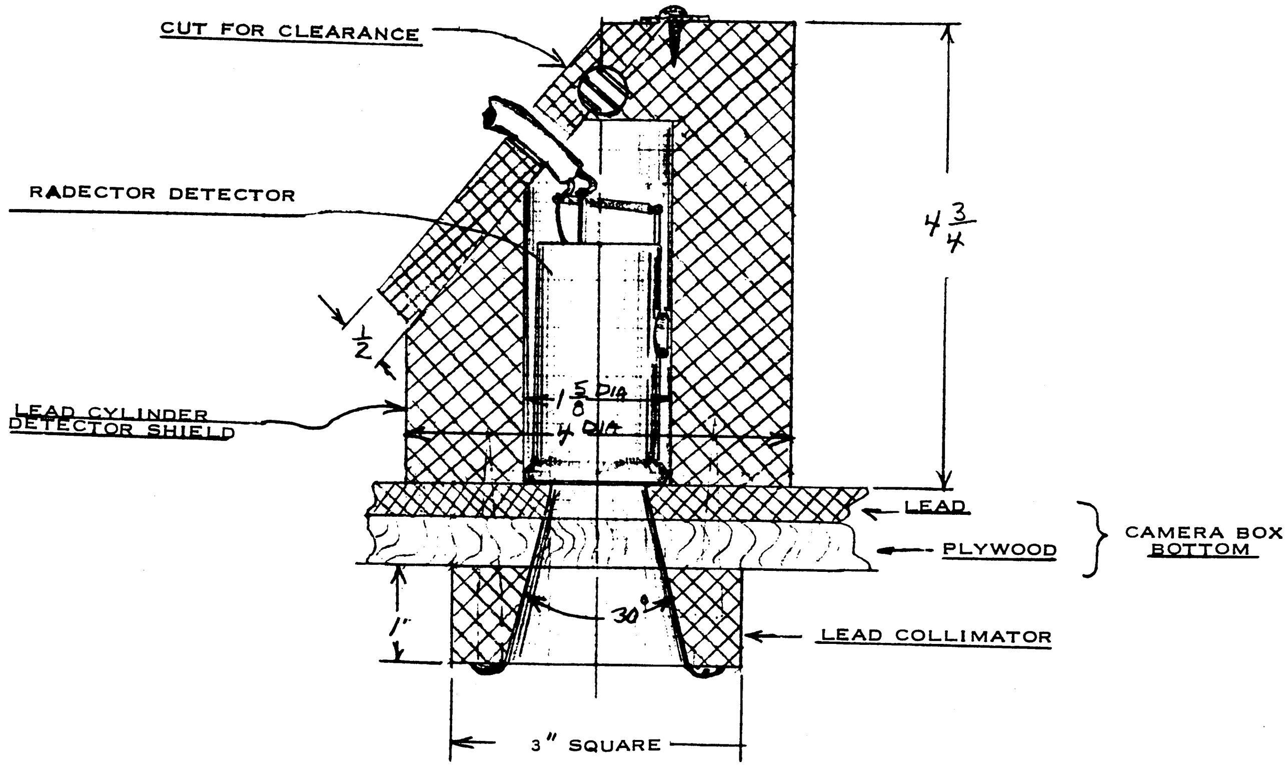
Film packs mounted in standard NRTS holders and containing a beta window with cadmium, silver and aluminum filters were used to establish gamma levels in the reactor building. By recording the exposure times and specific locations the films were in the reactor area, dose rates could be established at these locations. This technique allowed comparison of data from successive entries.

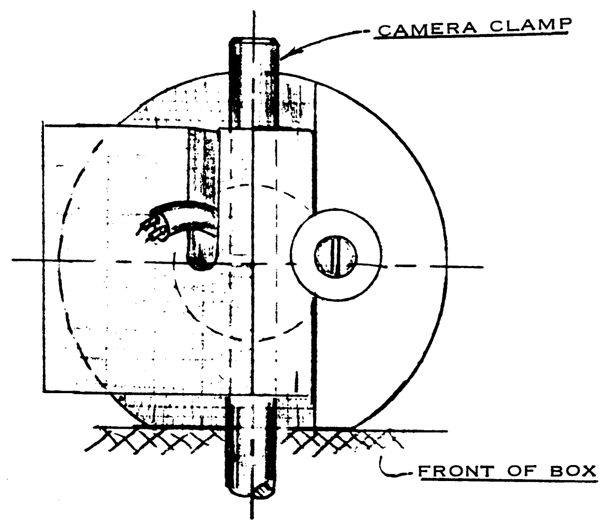
Processing and reading of the film was accomplished by the IDO Health Physics Division. The quoted accuracy on the film was $\pm$ 20% for the gamma dose.

A Jordan radector Model AGB500B was also attached to the movable crane boom during penetrations in the reactor room. The radector was fitted with a 50 foot extension from the chamber to the power supply and read-out system to allow the boom operator to observe dose rate readings remotely. Calibration of this instrument above 1 r/hr is poor resulting in at least a $\pm$ 20% error on the results from this detector. This detector has essentially a uniform response with respect to indicated radiation intensity versus gamma ray photon energy for photon energies from 80 kev to 1.2 inches mev.

Inside the vessel gamma doses were established using chemical dosimeters produced by E. G. and G. Each dosimeter packet consisted of three dosimeters having overlapping sensitive ranges thus allowing multiple readings for accuracy. Two types of packets were available, one ranging from 25 r to 10^3r and the other ranging from 10^3 to 10^6 r. The accuracy of these dosimeters was $\pm$ 20%.

In conjunction with a movie camera survey of the reactor operating floor and ceiling, a collimated ion chamber survey was conducted. The ion chamber used the modified Jordan radector mounted in a collimator placed in the lead lined movie camera box as shown in Figure II-44. A second movie camera was mounted to record the radector readings and operated in conjunction with the camera scanning the operating room.





LEAD COLLIMATOR AND SHIELD FOR RADIATION DETECTOR

FIGURE II-44

This technique allowed accurate correlation of the detector reading with position. Since only relative dose rates were of interest, no attempt to calibrate the system for absolute dose rate was made.

The detection of neutrons in the vessel was accomplished by exposing indium, gold, nickel, copper, and sulphur foils. Standard neutron foil techniques were used.

b. Summary of Radiation Results

Radiation traverses were made from the cargo door entrance of the reactor building to port No. 8 with film badges placed along the length of the movable boom and with the Jordan radector located on the end of the boom. A typical traverse is shown in Figure II-45. The effect of radiation streaming through the vessel ports and general increase in radiation level over the vessel is evident. The ratio of the average dose rate over the vessel to that over the floor is 1.7.

Figure II-46 shows the radiation decay measured at five feet above the reactor vessel head during penetrations made between March 15 to May 17, 1961.

Figure II-47 shows the gamma dose rates measured in and above the reactor vessel throughout this period.

Neutron measurements were made with indium and gold foils inside the reactor vessel. Both the indium and gold foil data indicated that there is little or no thermalizing material in the reactor vessel. The fast neutron flux in the vessel was insufficient to activate the nickel and sulphur to a measurable level.

c. Technique for Location of High Radiation Sources

A joint collimated ion chamber survey and movie camera traverse of the reactor operating floor and ceiling was performed. The survey was a first attempt at developing techniques for locating major sources of radiation in the reactor building. While quantitative radiation levels and precise directional characteristics cannot be reported, the technique did provide relative radiation levels and therefore a radiation profile of the reactor room floor and ceiling.

A plot plan of the reactor operating floor with the path of the camera traverse is shown in Figure II-48. The height of the ion chamber above the operating floor was five feet ± six inches. The numbers along the traverse refer to the frame number of the movie film. Figure II-49 is a plan of the reactor operating room ceiling with the camera traverse path indicated. The ion chamber was four feet ± six inches below the ceiling. To locate specific readings in the figures, the reader should

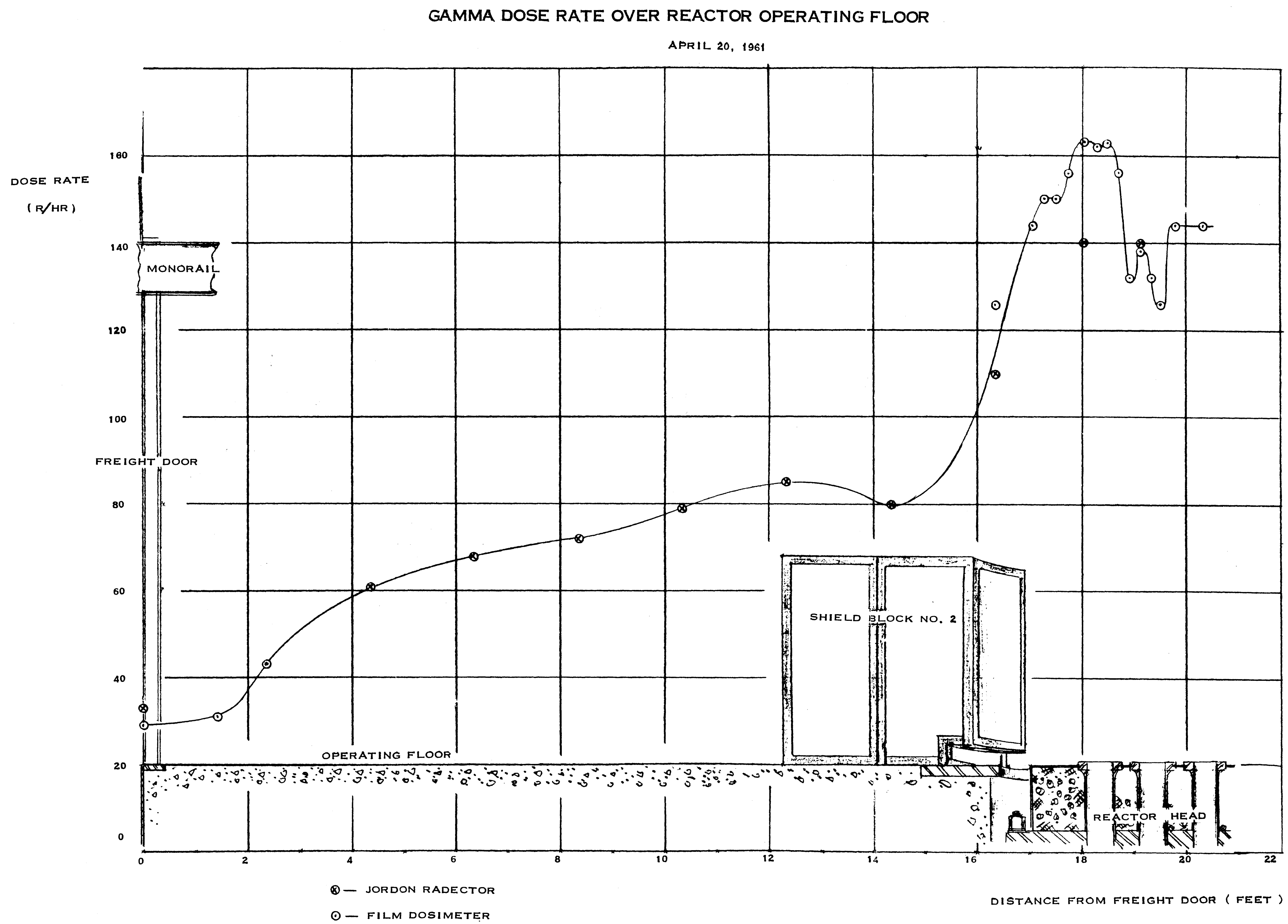
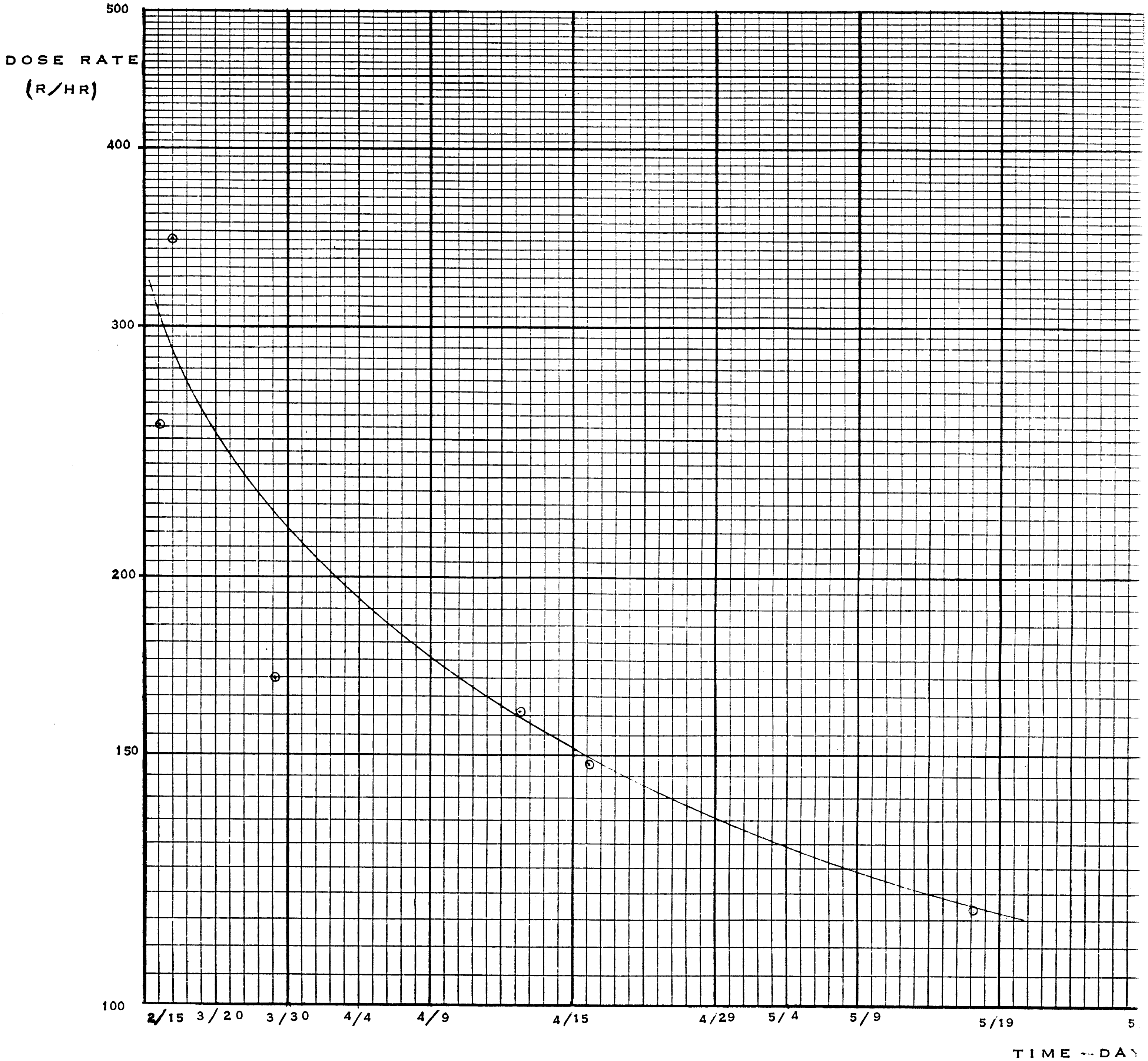
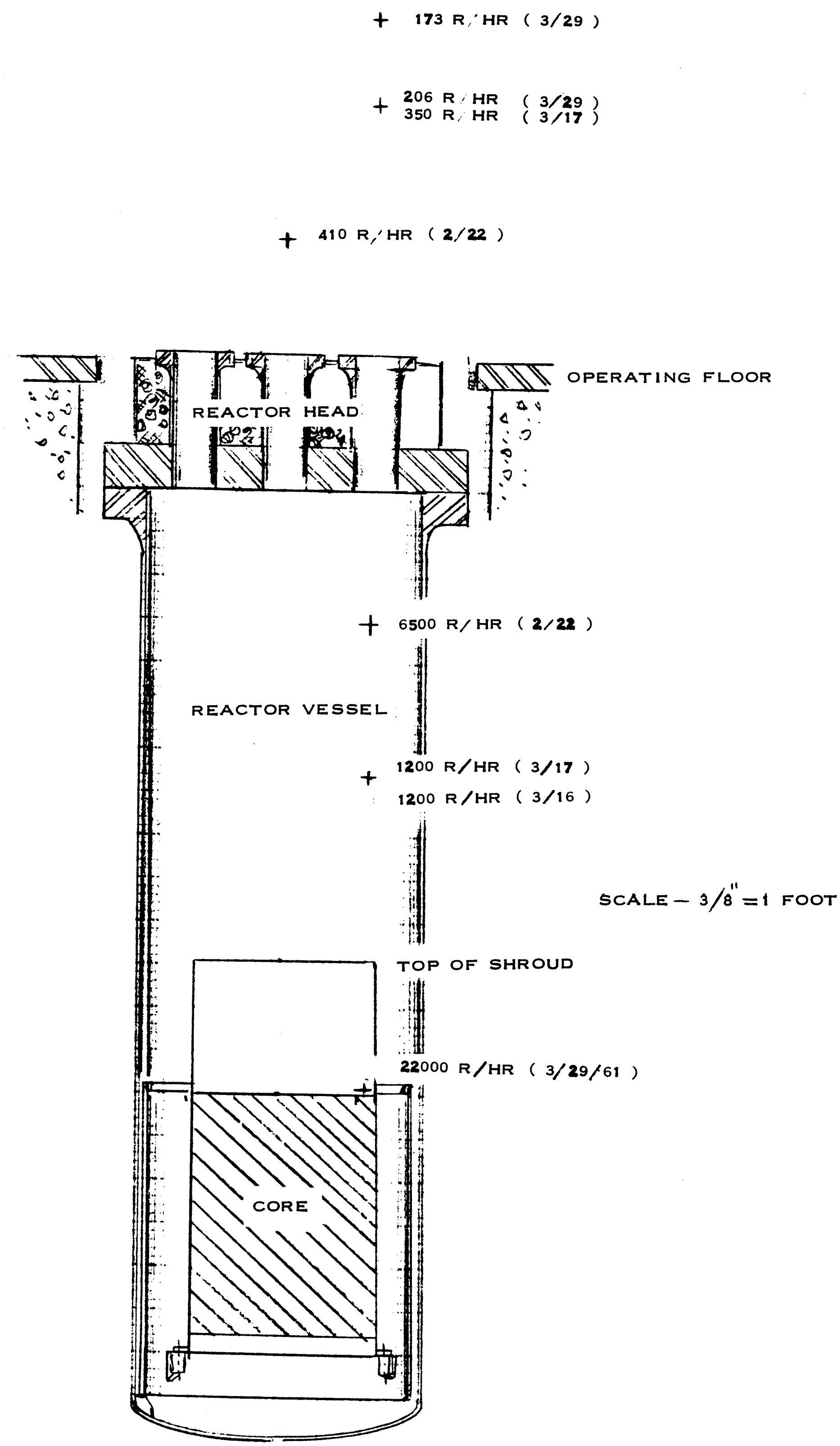

GAMMA DOSE RATE OVER REACTOR OPERATING FLOOR
APRIL 20, 1961
DOSE RATE
(R/HR)
160
140
120
100
80
60
40
20
0
MONORAIL
FREIGHT DOOR
OPERATING FLOOR
SHIELD BLOCK NO. 2
REACTOR HEAD
0
2
4
6
8
10
12
14
16
18
20
22
DISTANCE FROM FREIGHT DOOR (FEET)
⊗ — JORDON RADECTOR
⊙ — FILM DOSIMETER

FIGURE II-45



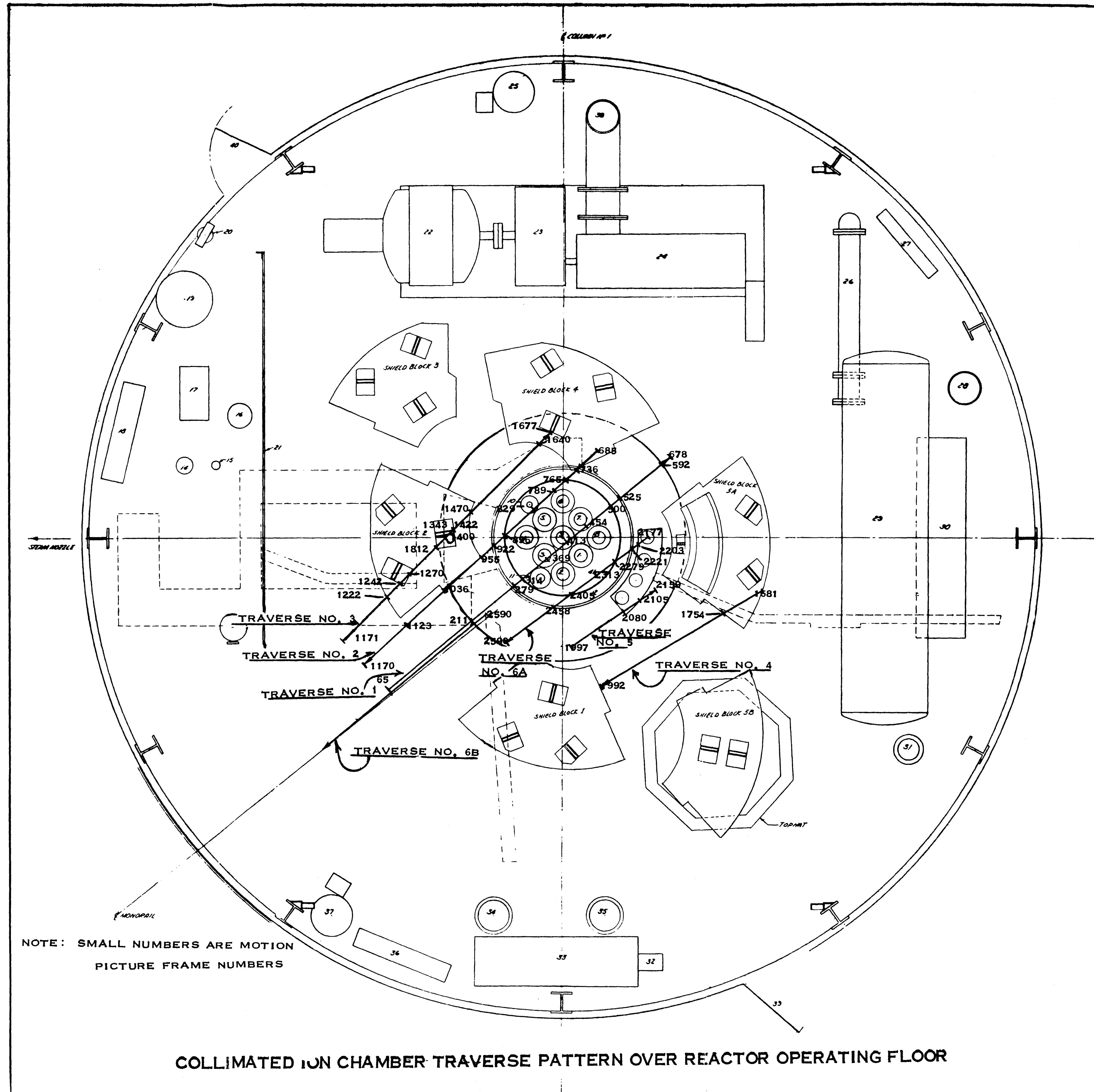
GAMMA DECAY OVER REACTOR VESSEL HEAD

FIGURE II-46



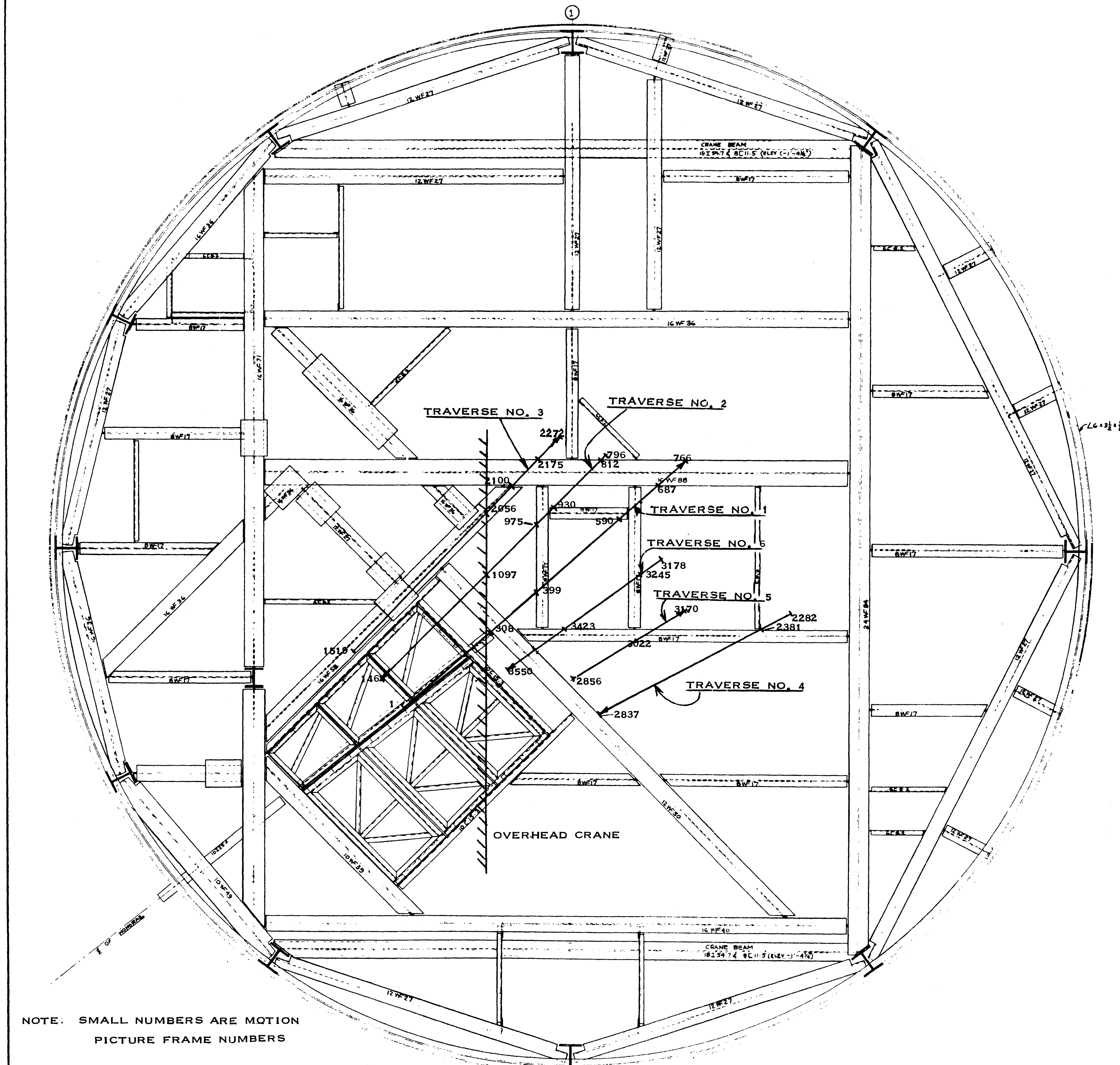
GAMMA DOSE RATES IN AND ABOVE THE REACTOR VESSEL

FIGURE II-47



COLLIMATED ION CHAMBER TRAVERSE PATTERN OVER REACTOR OPERATING FLOOR

FIGURE II-48



COLLIMATED ION CHAMBER TRAVERSE PATTERN UNDER REACTOR CEILING

FIGURE II-49

establish the frame number associated with the reading and locate this frame number by extrapolation between the recorded frame number. Add or subtract five inches, depending on direction of the traverse. The reading of the collimated ion chamber was one when aligned at the cargo door pointing toward the floor.

Floor traverse No. 1, Figure II-50, shows the streaming of radiation through ports No. 3 and No. 9 and also indicates, by the general rise in level as the detector passed over the reactor vessel, that a large portion of the radiation in the reactor building is coming from the top of the reactor vessel. The increase in level in the vicinity of frame No. 165 corresponds to an accumulation of blotter paper in this region.

Floor traverse No. 2, Figure II-51, also shows the effect of passing over the vessel. The large peak corresponds to port No. 4.

Floor traverse No. 3, Figure II-52, shows the accumulation of radioactive material in the lifting eye indentations in the shield blocks. The high intensity relative to measurements over the vessel is misleading, since the distance between the top of the shield block and the detector was approximately six inches compared to five feet over the vessel. The peaks occurring at frame Nos. 1256, 1320, and 1675 correspond to the indentations in the shield plugs. Repositioning of the boom was required when it ran into the crane hook at frame 1370 resulting in discontinuity of frame number at this point. This traverse shows the effectiveness of this system for location of hot spots. Figure II-53 indicates a generally high level in the vicinity of frames 1850 to 2000.

Ceiling traverse No. 1, Figure II-54, shows the relative radiation coming from the ceiling directly over the vessel. It is interesting to note that the peaks from frames 300 to 400, and 500 to 600 correspond with the I beams in the ceiling and that the shield plug located in the ceiling in the vicinity of frames No. 450 to 470 does not indicate a high radiation source.

Shielding around the collimated ion chamber, including the lead in the camera box, was 1-1/2 inches of lead. Based on the general dose rate levels measured over the reactor vessel during previous entries, it is estimated that at least 50% of the radector reading over the vessel is attenuated radiation from the core. Ceiling traverses No. 6 through 6 indicates that there are no spots on the ceiling with intensities greater than the scattered radiation, general contamination or attenuated direct beam radiation passing through the collimator shield.

This method of radiation survey is believed to be adequate for locating regions of high radiation levels.

COLLIMATED ION CHAMBER TRAVERSE NO. 1.

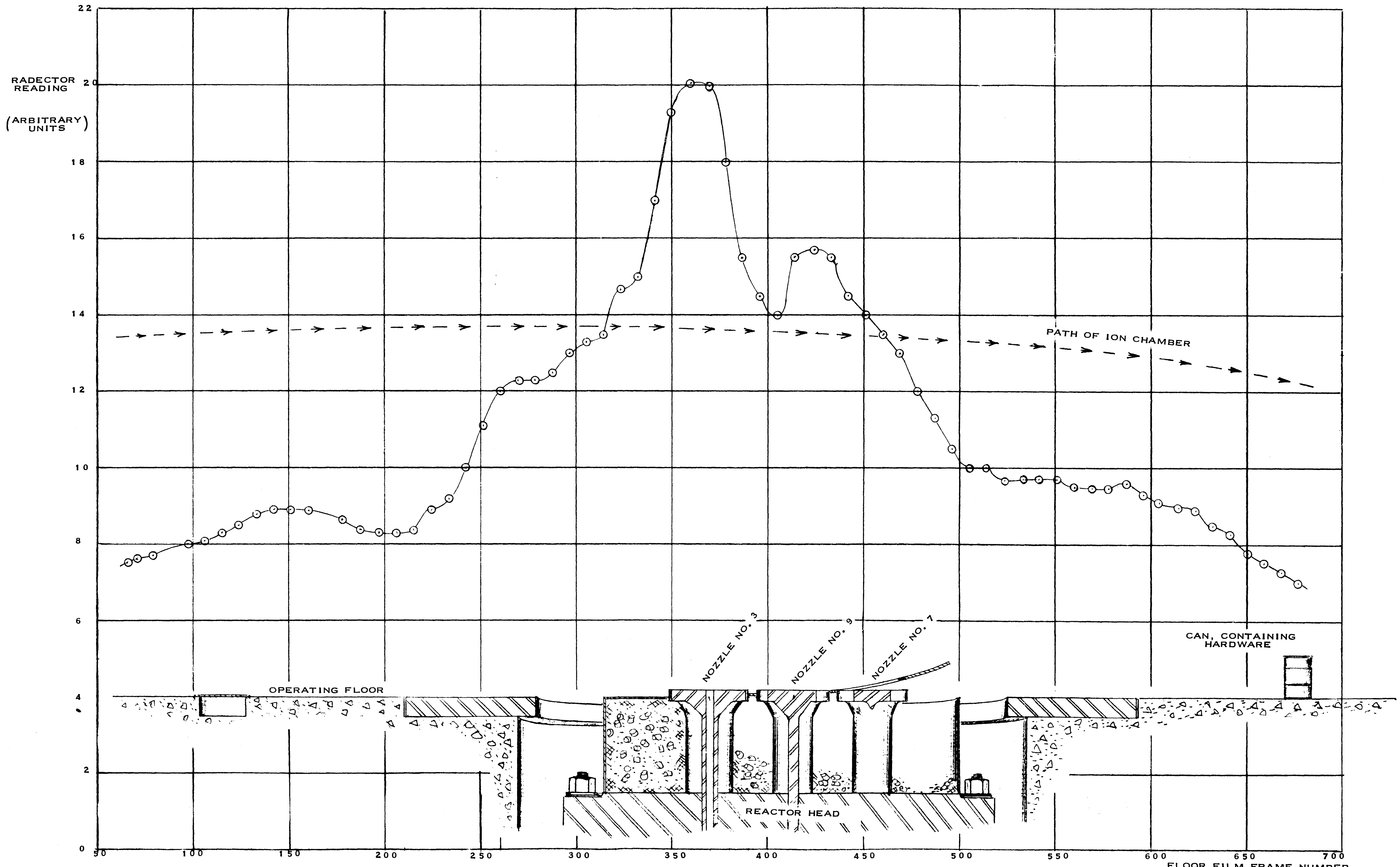


FIGURE II-50

COLLIMATED ION CHAMBER TRAVERSE NO. 2

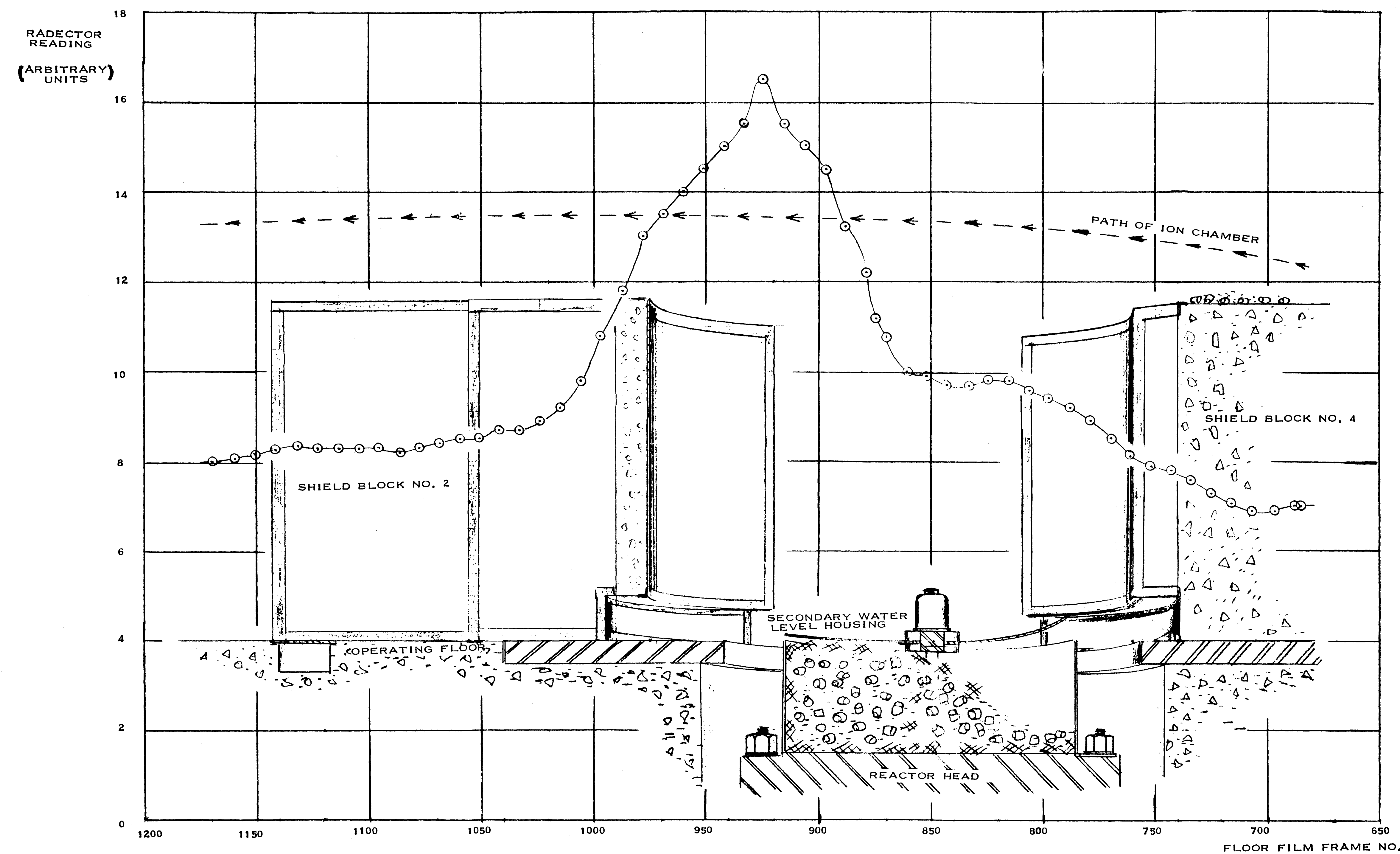


FIGURE II-51

COLLIMATED ION CHAMBER TRAVERSE NO. 3

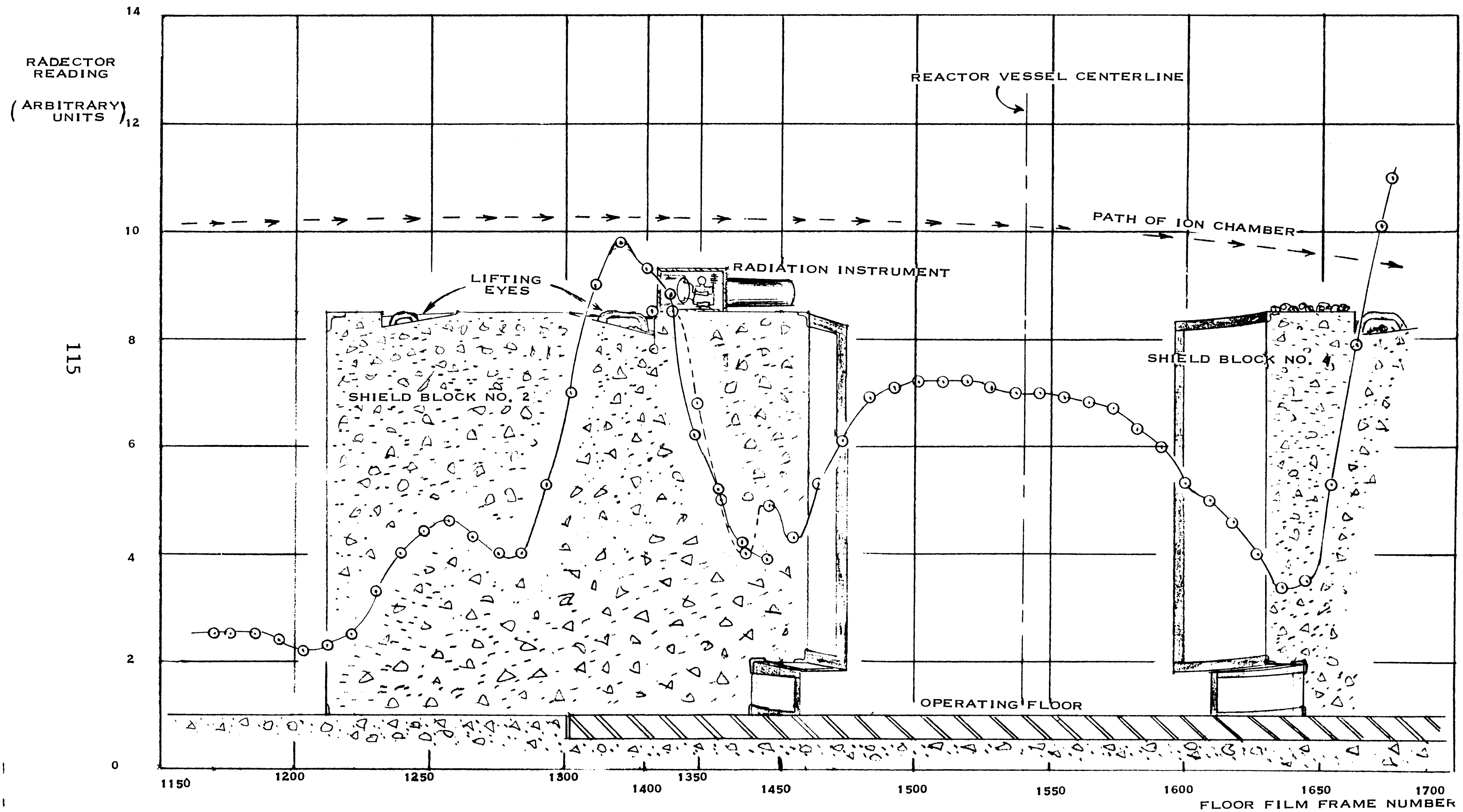


FIGURE II-52

COLLIMATED ION CHAMBER TRAVERSE NO. 4

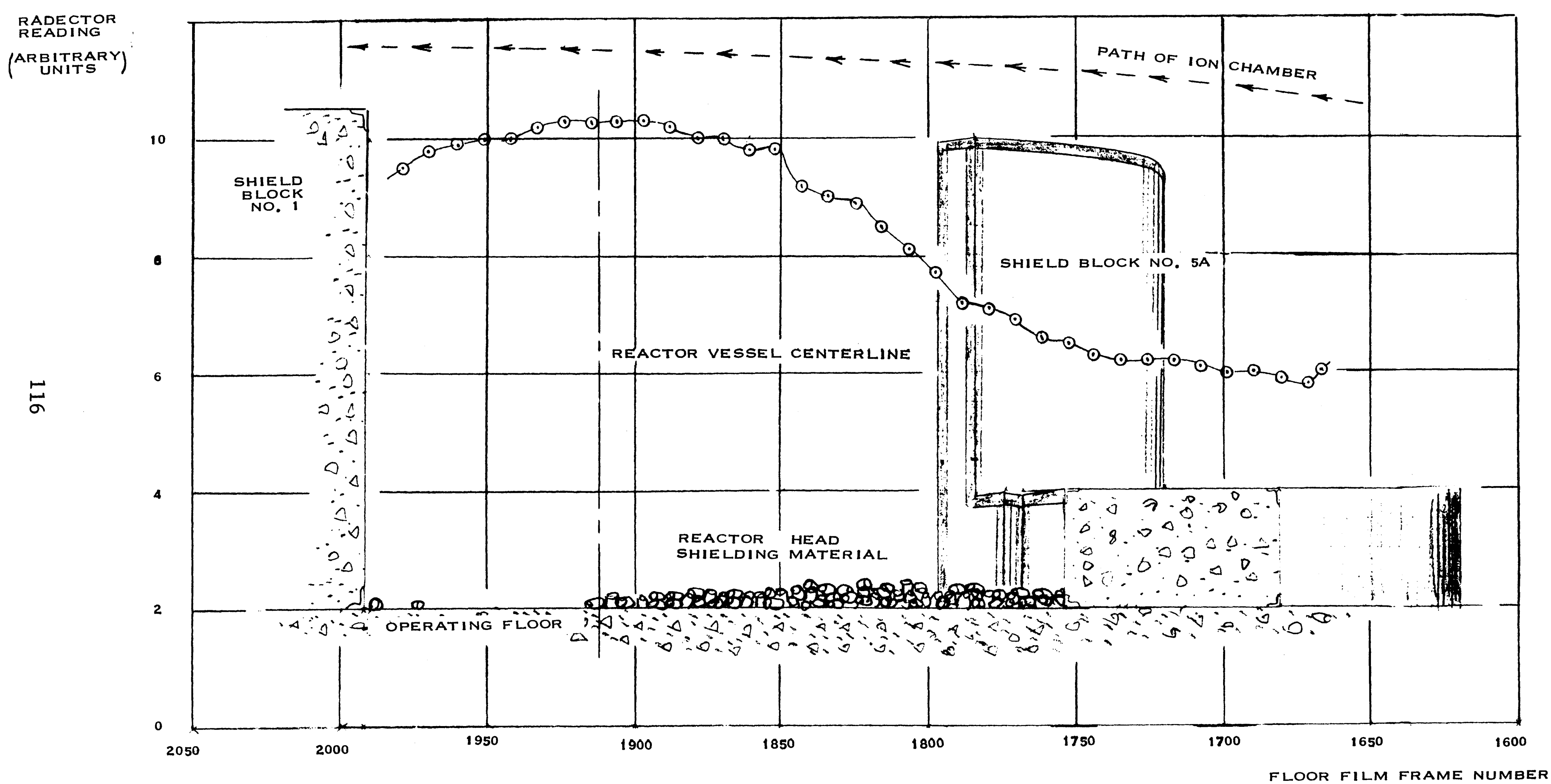


FIGURE II-53

COLLIMATED ION CHAMBER TRAVERSE NO. 1

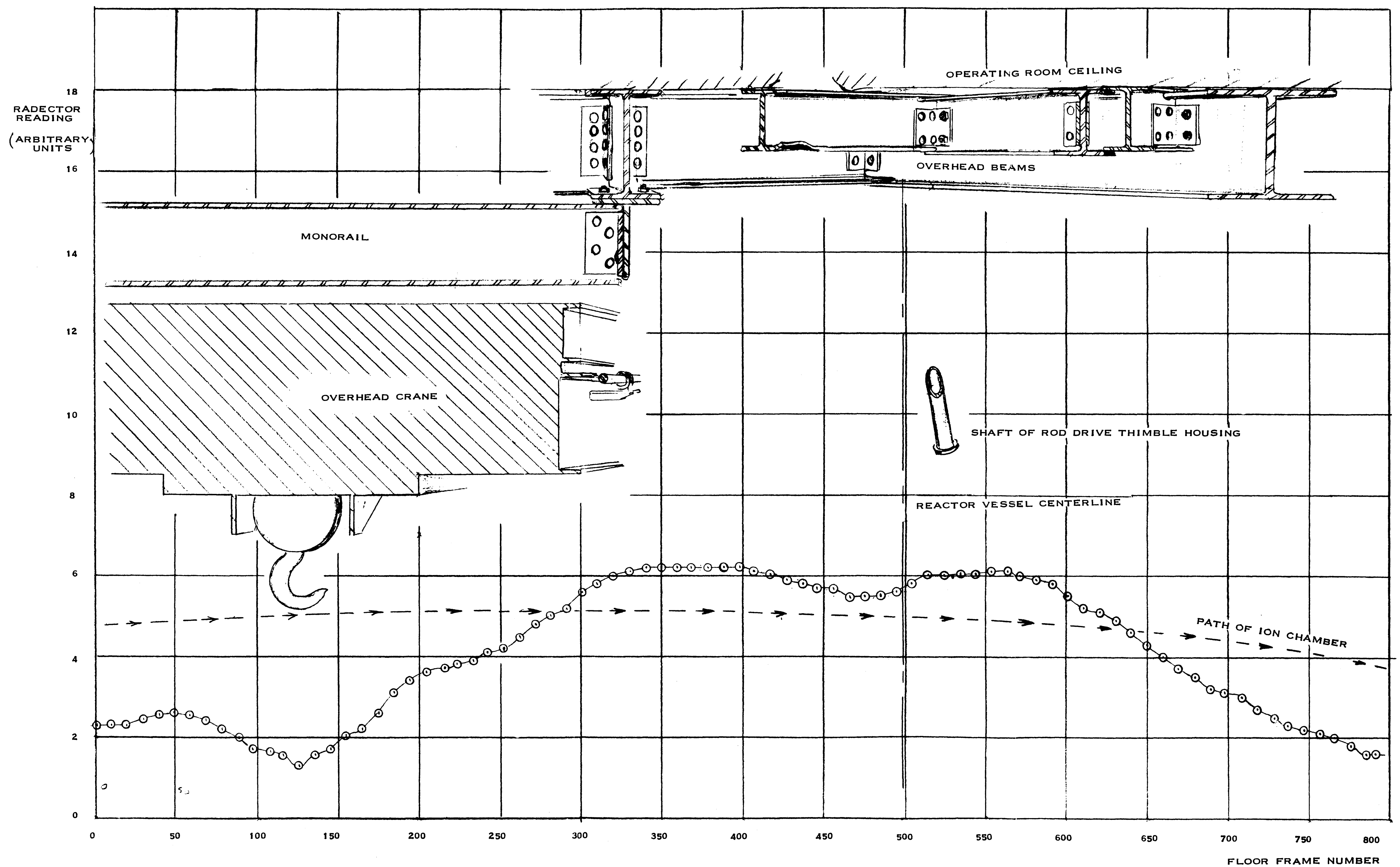


FIGURE II-54

2. Outside Reactor Building

Radiation surveys were made to determine the position of isodose curves and radiation decay. Specific radiation checks were made prior to recovery operations to enhance an accurate estimate of personnel exposures. All radiation measurements were made with Standard Range (0-5r) Juno Ionization Chamber type instruments.

a. Isodose Curves

Isodose curves were plotted from radiation intensity data. The first comprehensive isodose survey was made on January 18, fifteen days after the SL-1 incident. Subsequent surveys were made twice each month. Figure II-56 shows the position of the 500 mr lines as determined on January 18, February 18, March 21, April 24, and May 19. Figures II-55, 57, 58, 59, and 60 give complete data on the isodose lines for these dates. Revealed in these figures is the rapid radiation decay experienced in the first six weeks and then, the slower decay through the ensuing months.

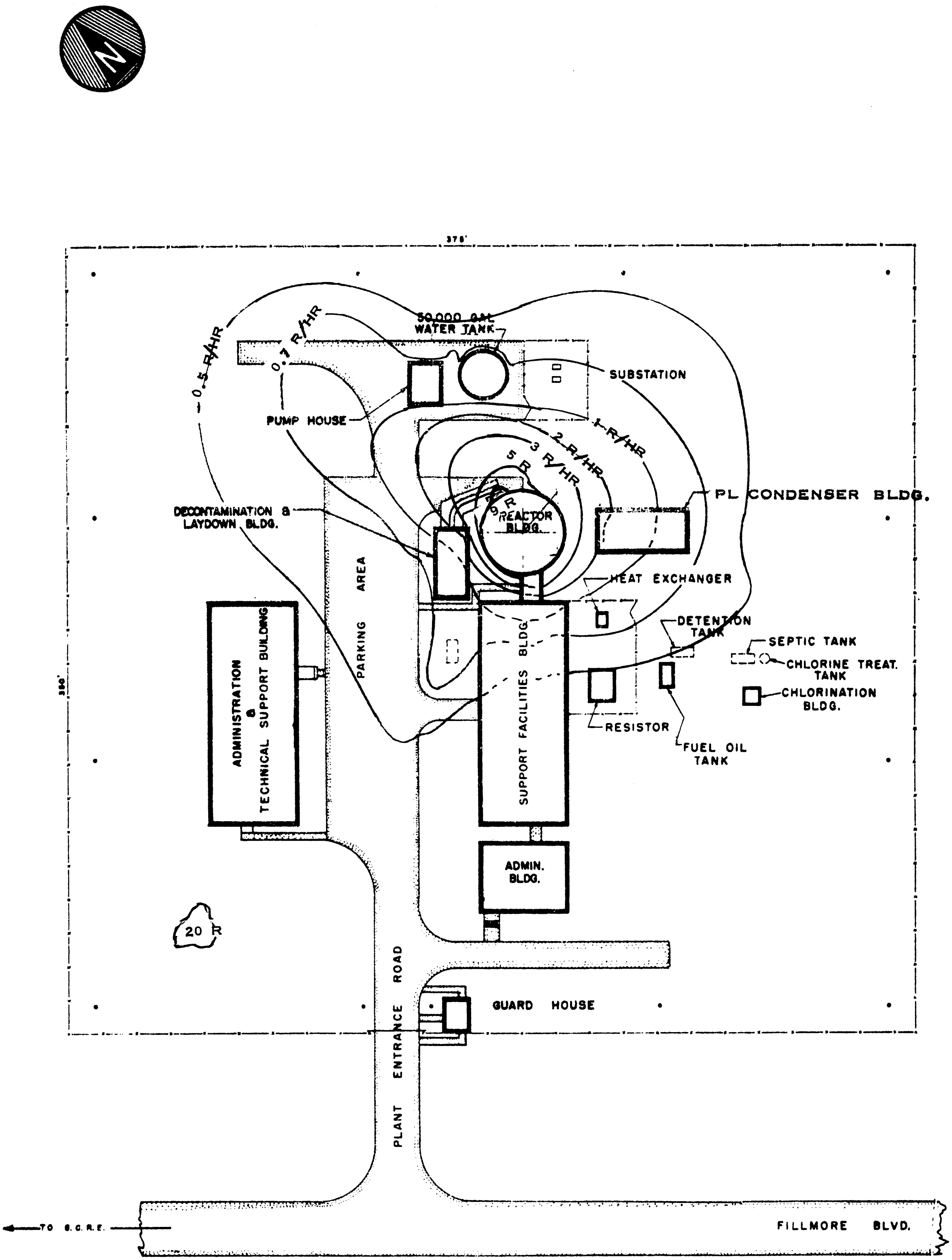
b. Radiation Decay

Decay of the gamma radiation eminating from the reactor building was determined by taking periodic radiation measurements at the fence in the East corner of the Site. The readings are plotted in Figure II-61 to show the increasing half life of the gross fission product activity.

c. Air Samples

Air samples were collected with four Staplex Hi-Volume air samplers adapted with large area sampling heads. This type sampler (located on the SL-1 fence, Figure II-62 consists of a prefilter which serves to collect airborne particulate material and a chemical cartridge (carbon media) to detect gaseous radioactivity. The air samples were analyzed for gross gamma activity. Periodic spectral analyses were performed in order to identify the contributing radionuclides.

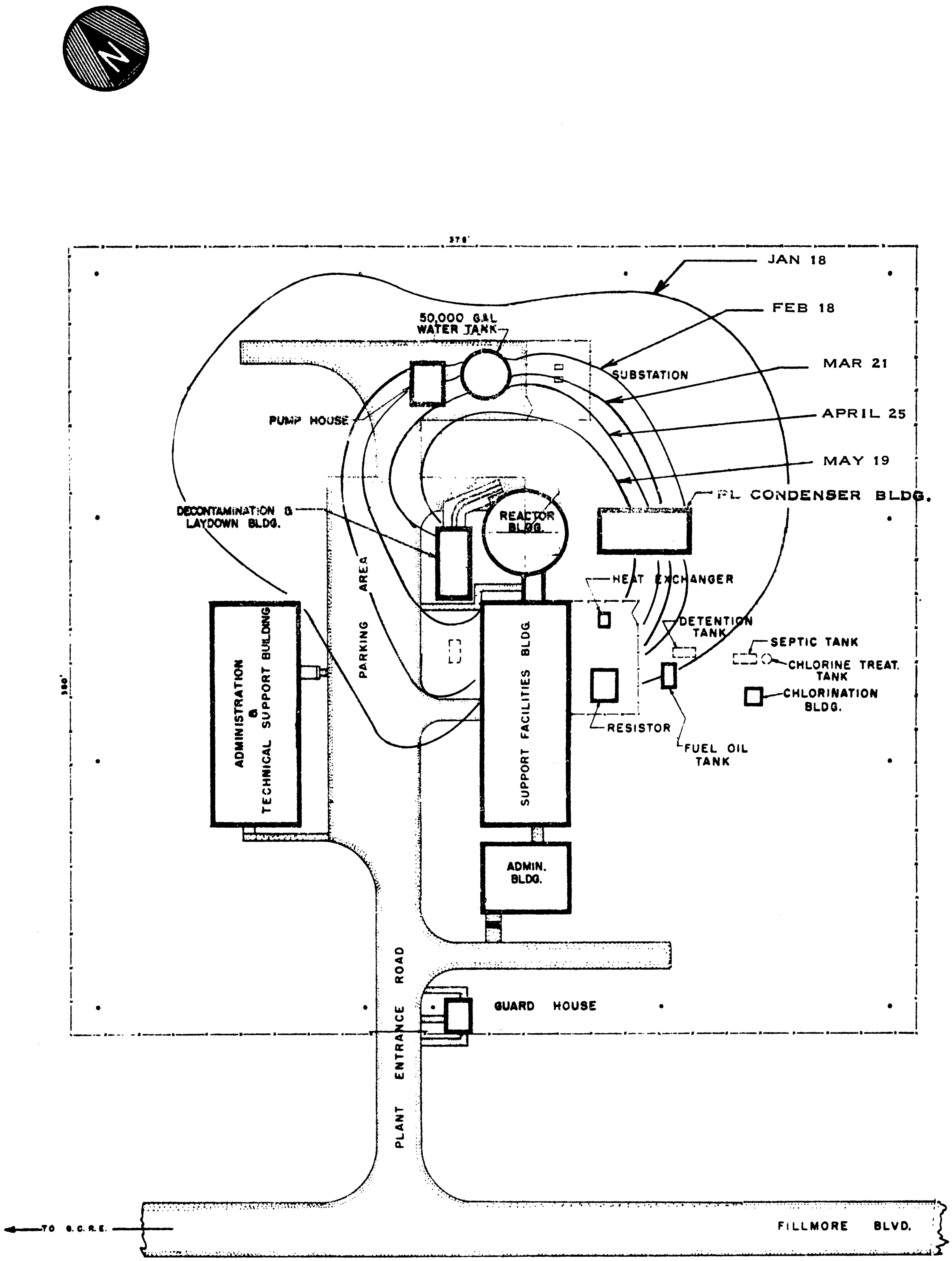
Air sampling inside the fence was initiated in February and maintained on a continuous basis. During the month of February, the air concentrations for radioactive iodine averaged 22×10^{-10} uc/cc. The average airborne radioactivity gradually decreased to concentrations of less than 1.0×10^{-12} uc/cc for radioactive iodine and other fission products. In May gamma spectral analyses identified $Zr\text{-}Nb^{95}$, $Ru^{103\text{-}106}$, I^{131}, Cs^{137} and $Ce^{141\text{-}144}$ as the major radionuclides contributing to these airborne concentrations of radioactivity. Table A summarizes the monthly average of air concentrations within the SL-1 Site.



SL-1 SITE ISODOSE LINES

JANUARY 18, 1961

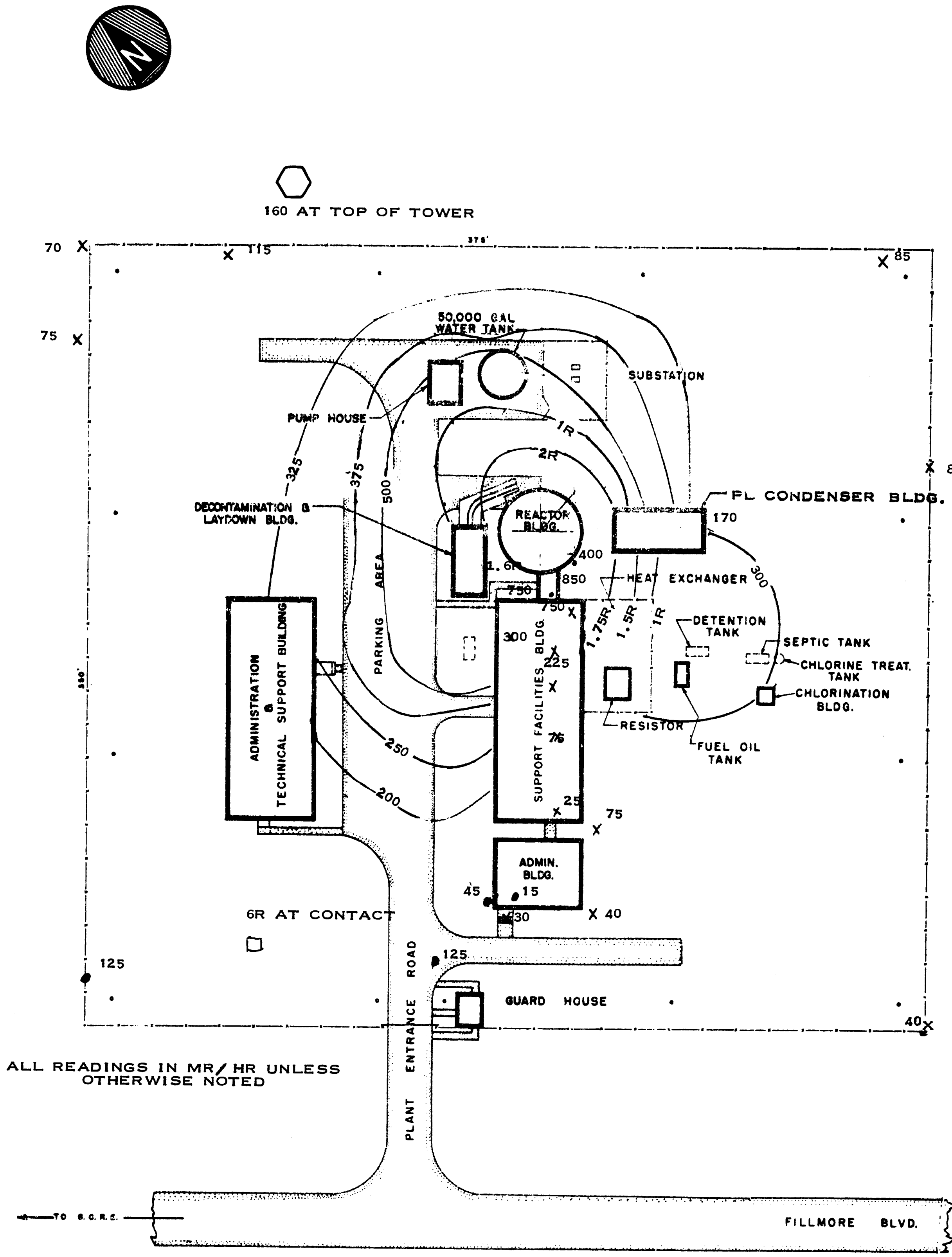
FIGURE II-55



SL-1 SITE ISODOSE LINES

500 MR/HR LINES

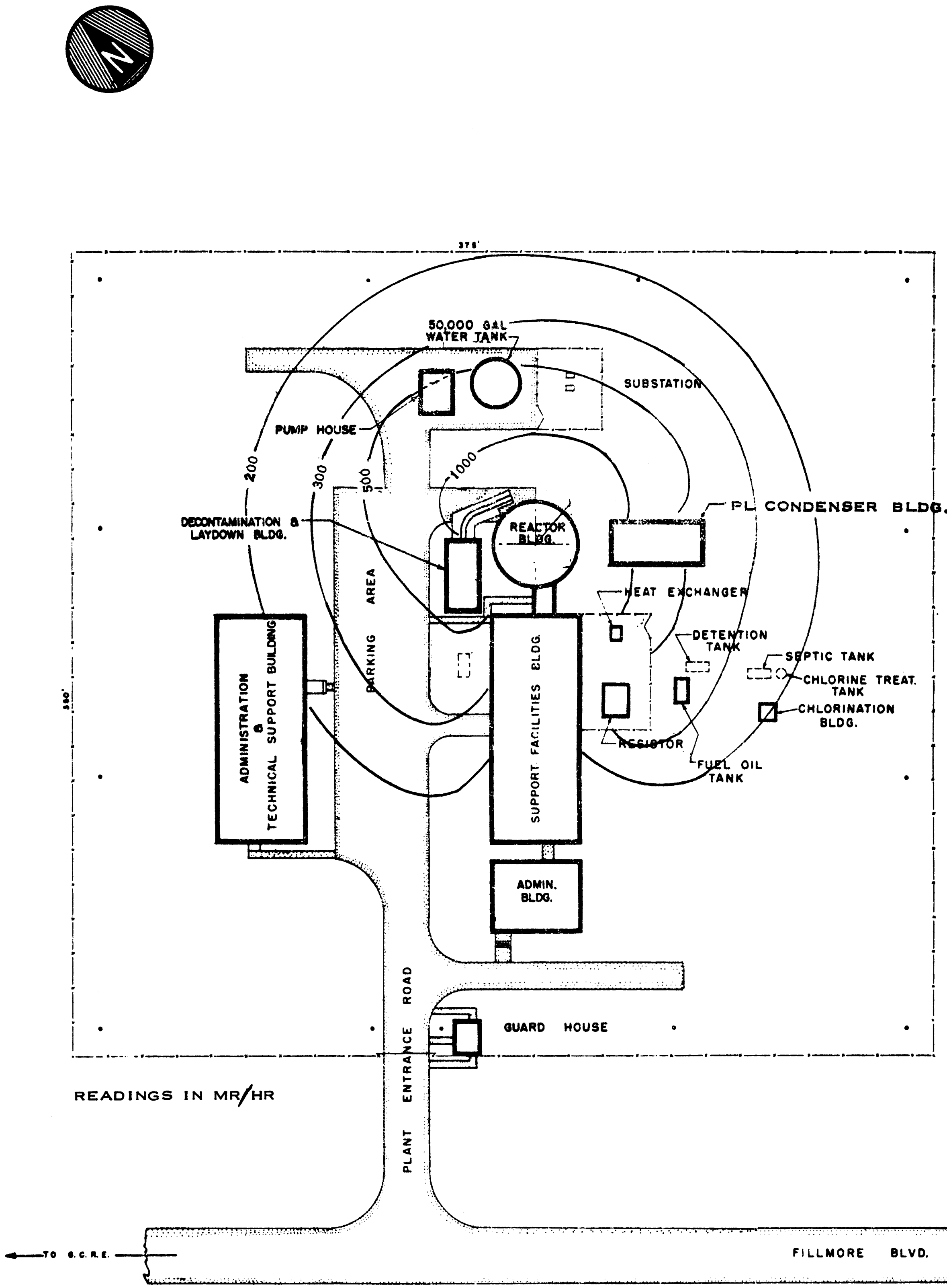
FIGURE II-56



SL-1 SITE ISODOSE LINES

FEBRUARY 18, 1961

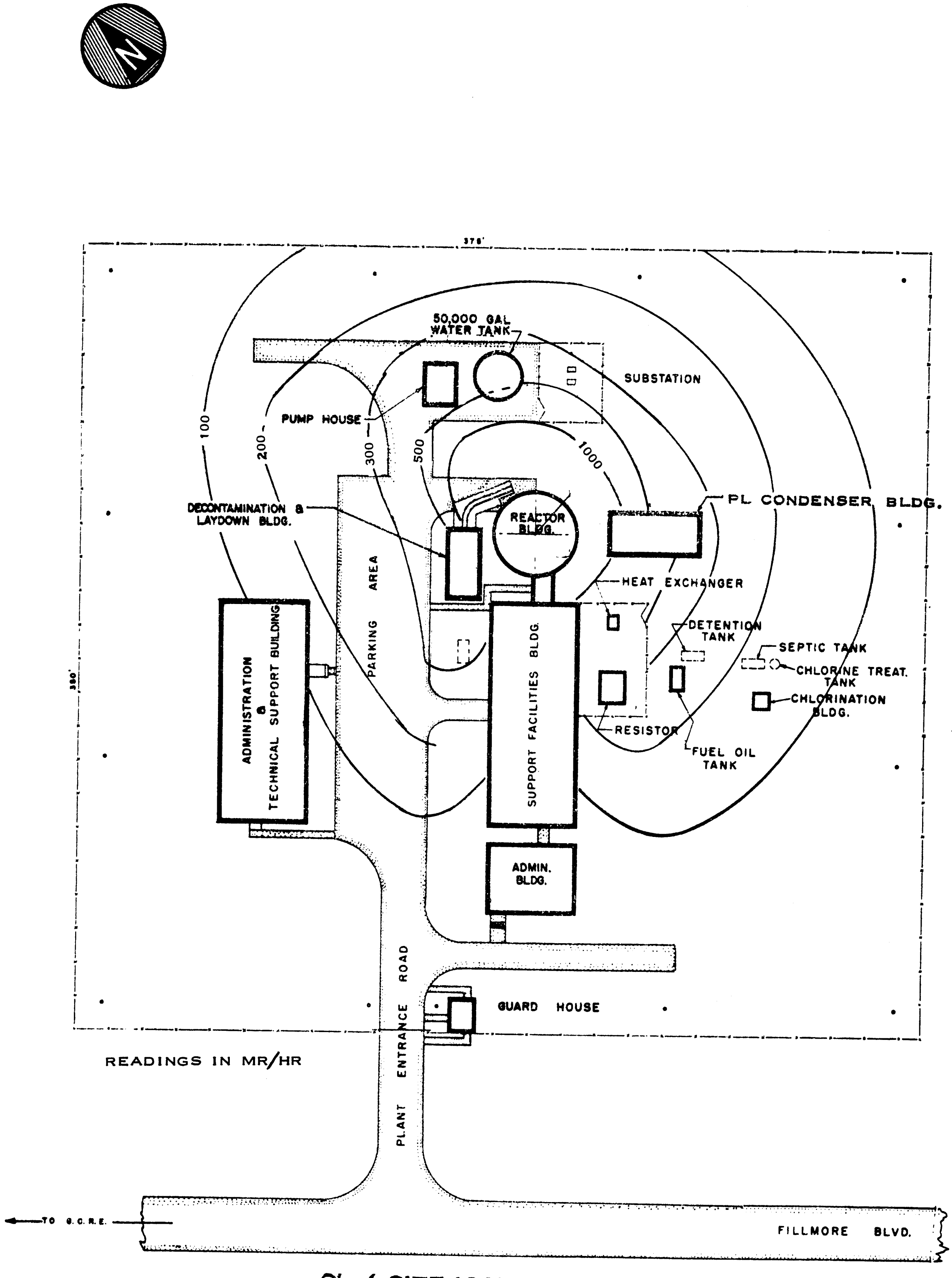
FIGURE II-57



SL-1 SITE ISODOSE LINES

MARCH 21, 1961

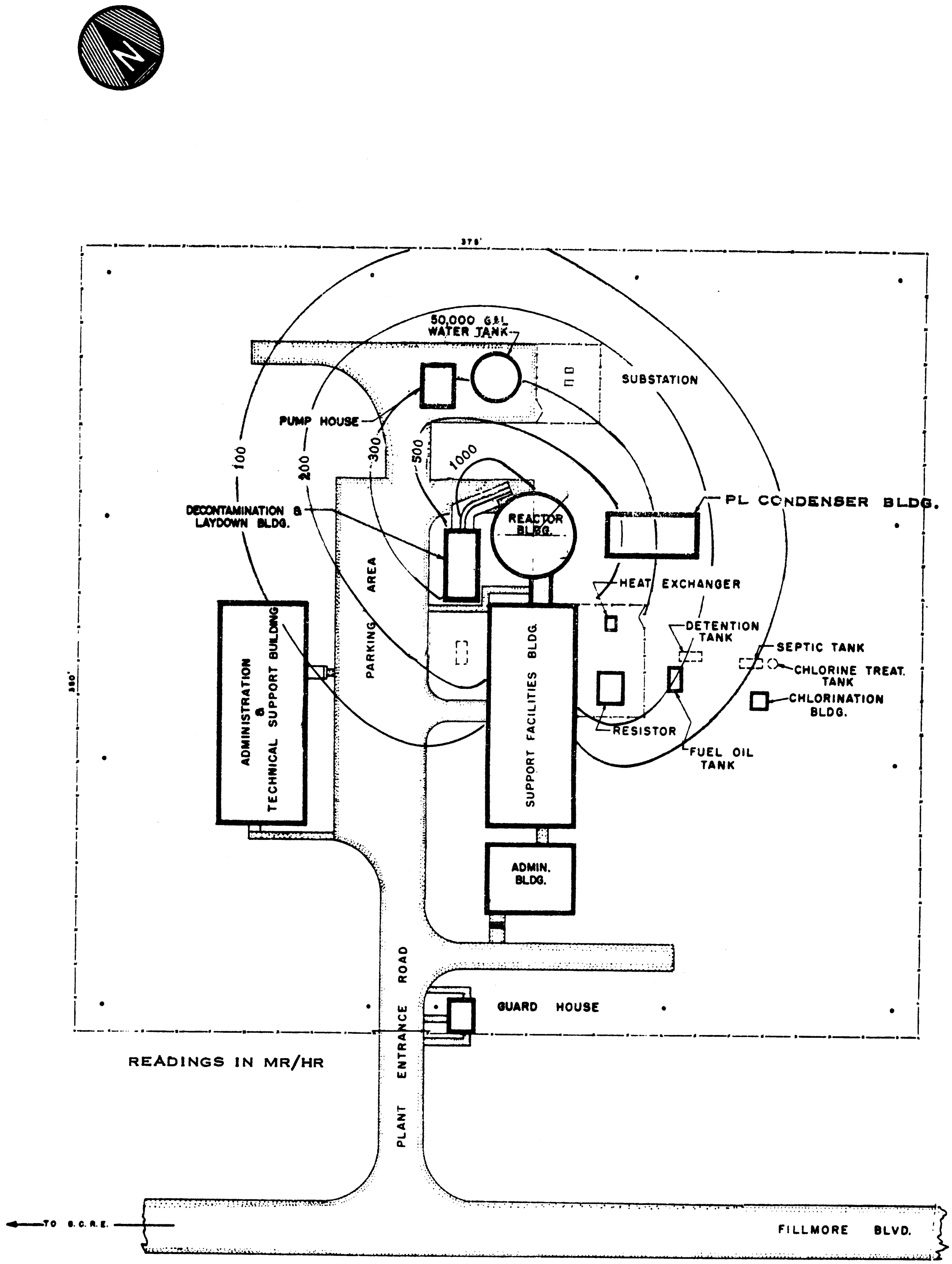
FIGURE II-58



SL-1 SITE ISODOSE LINES

APRIL 24, 1961

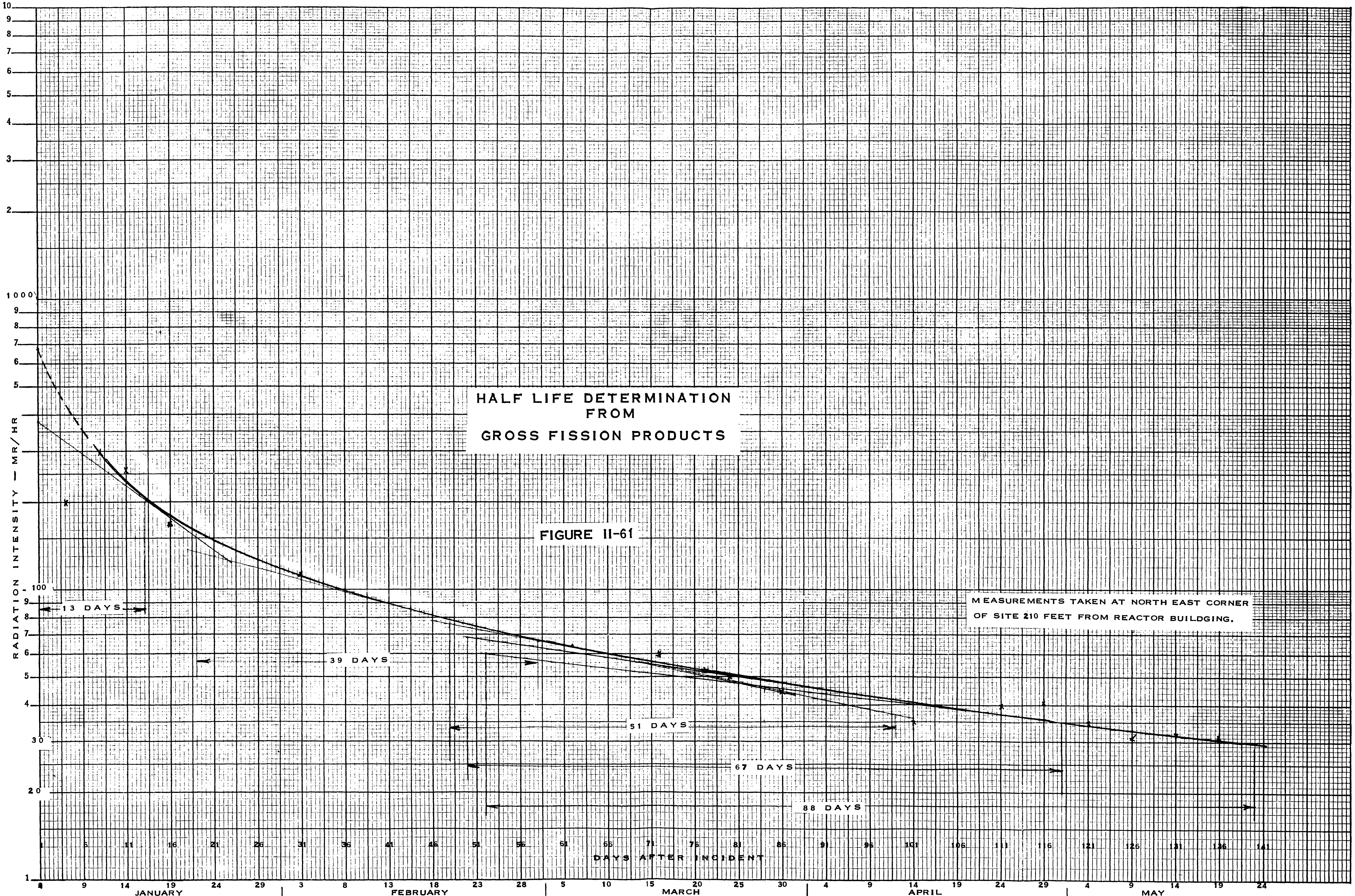
FIGURE II-59



SL-1 SITE ISODOSE LINES

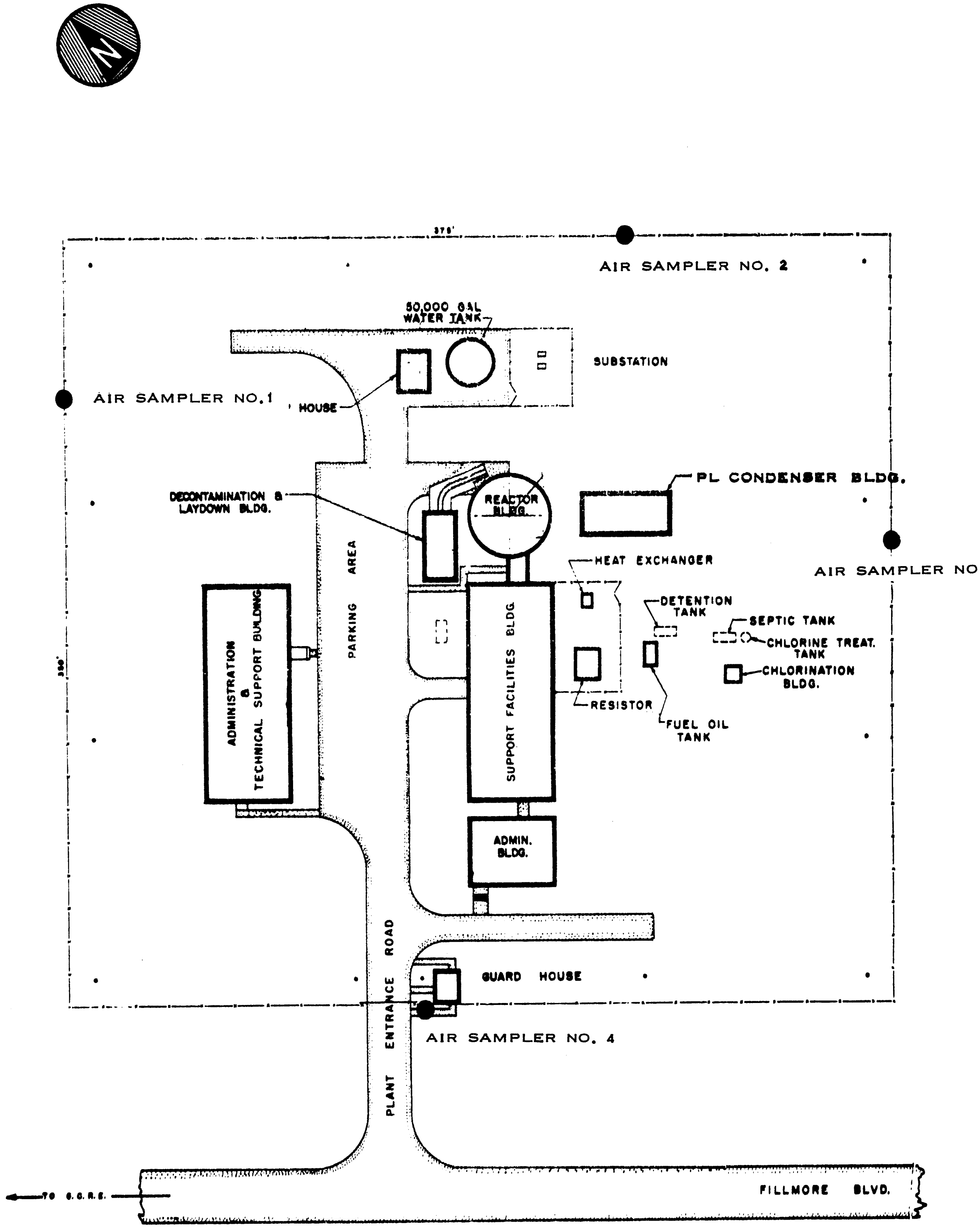
MAY 19, 1961

FIGURE II-60



HALF LIFE DETERMINATION FROM GROSS FISSION PRODUCTS

FIGURE II-61



LOCATION OF AIR SAMPLERS AT SL-1 SITE

FIGURE II-62

TABLE A

IODINE^{131} CONCENTRATIONS IN AIR FOLLOWING SL-1 INCIDENT

Month	Air Concentration - I^{131} mc/cc
February	2.2×10^{-10}
March	8.0×10^{-11}
April	3.5×10^{-11}
May	1.0×10^{-12}

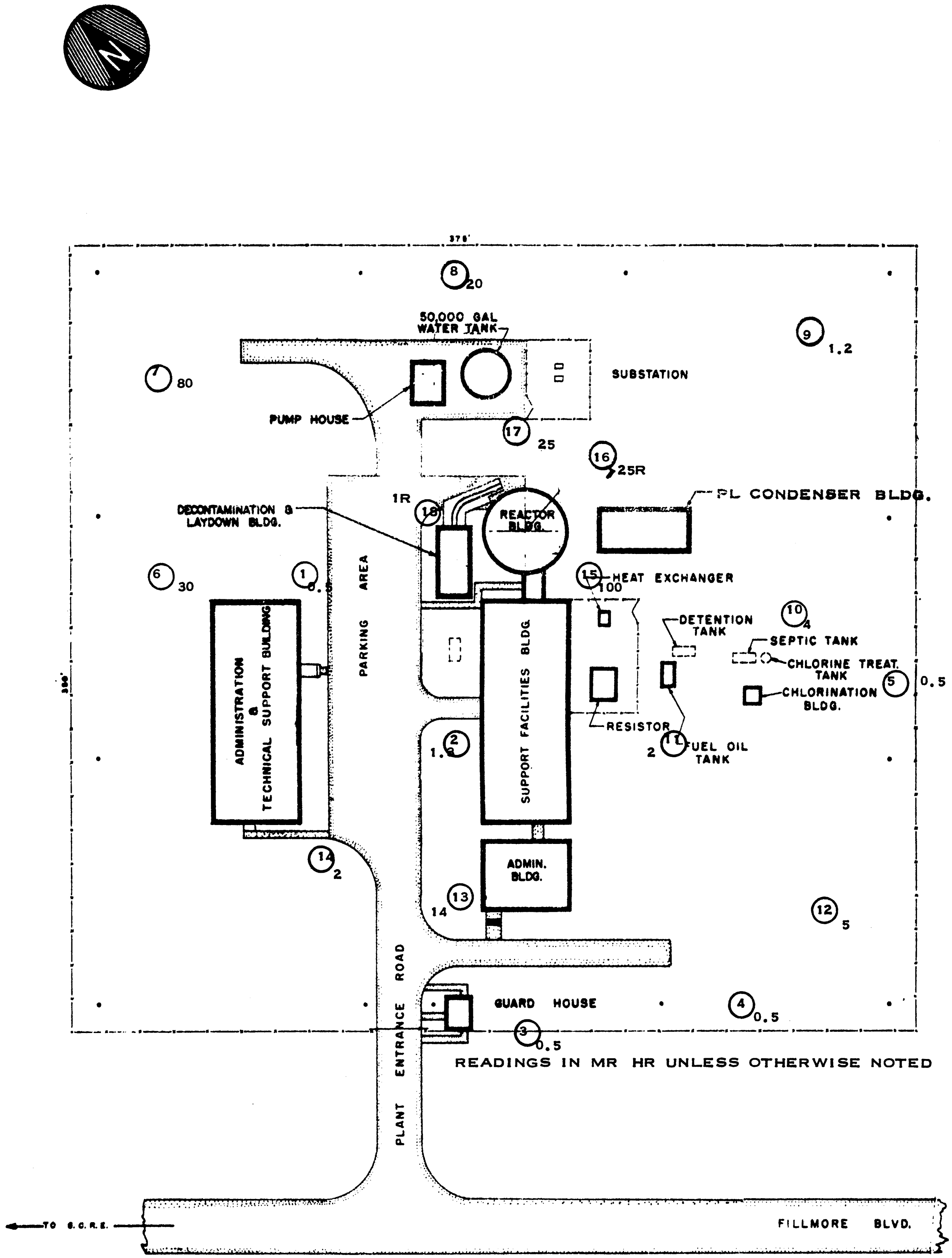
d. Soil Samples

A program of soil sampling within the SL-1 perimeter fence was performed during the 45 day period following the incident. Five samples were taken on January 13, 1961 and 13 samples were collected on February 17, 1961. Figure II-63 presents the sampling locations with direct radiation readings.

The samples were submitted for gamma scanning and radiochemical analysis for Sr^{90}. A gamma spectra of the January 13 samples indicated the presence of I^{131}, Ba^{140}, La^{140}, Cs^{137}, Ce^{144}, Zr^{95}, and Nb^{95}. Samples taken on February 17 varied considerably in nuclides identified as well as concentration.

Particulate nuclides, i.e., La^{140}, Ce^{144}, Rw^{106}, Zr^{95}, and Nb^{95} were observed in samples taken near the building, but not in samples from the periphery of the site. These data indicate that a narrow range of dispersion of particulate fission products resulted from the incident.

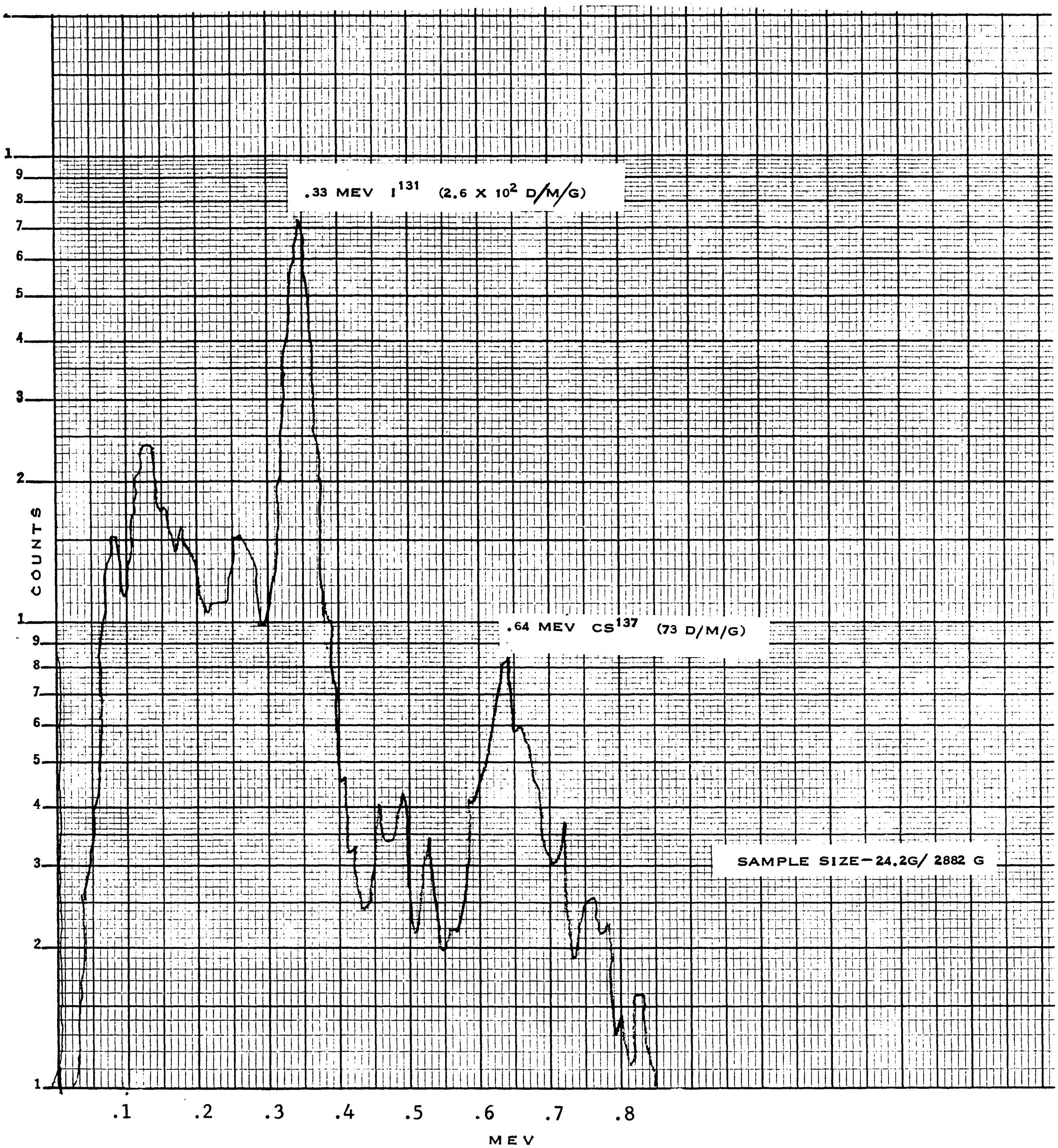
A typical gamma spectron for the peripheral samples is shown in Figures II-64 and II-65. Strontium 90 was significantly higher in concentration in three samples taken from the Northeast quadrant of the site, indicating that soluble strontium was dispersed in water or steam blown from the reactor.



SL-1 SITE

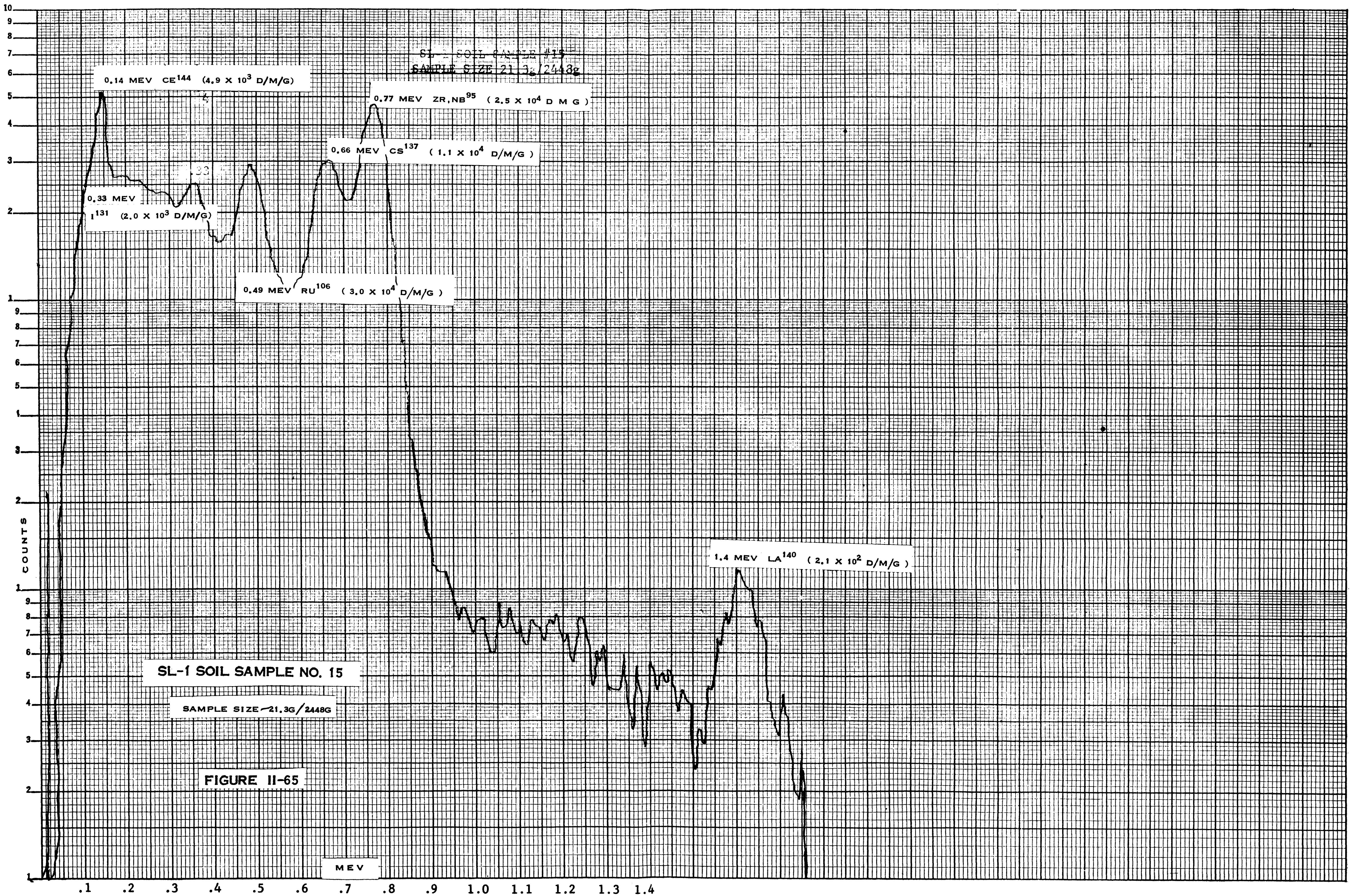
SOIL SAMPLE LOCATIONS

FIGURE II-63



SL-1 SOIL SAMPLE NO. 12

FIGURE II-64


0.14 MEV CE^{144} (4.9 X 10^3 D/M/G)
0.77 MEV ZR,NB^{95} (2.5 X 10^4 D M G)
0.66 MEV CS^{137} (1.1 X 10^4 D/M/G)
0.33 MEV
I^{131} (2.0 X 10^3 D/M/G)
0.49 MEV RU^{106} (3.0 X 10^4 D/M/G)
1.4 MEV LA^{140} (2.1 X 10^2 D/M/G)
COUNTS
SL-1 SOIL SAMPLE NO. 15
SAMPLE SIZE–21.3G/2448G
MEV
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4
FIGURE II-65

e. Radiation Survey Equipment

The equipment which was used by Health Physics personnel for measuring radiation levels, collecting air samples, etc. is shown in Figure II-66 and is listed below:

(1) Portable spot floodlight

(2) Geiger-Muller survey instrument (0-20mr) utilized primarily for contamination surveys

(3) Portable walkie-talkie phones utilized for communication between Control Point and SL-1 plant

(4) Portable sound amplified megaphone used during pre-operations briefings

(5) Spotting scopes used at Control Point to observer operations at SL-1 plant

(6) Hi-Volume air samplers adapted with large volume heads

(7) Juno radiation survey instrument (0-5 r; 0-25 r); note plastic covering to prevent contamination of instrument

(8) Full-face Army assault mask, half-face respirator, and self-contained Scott Air Pak utilized for respiratory protection

(9) High range Jordan survey instruments (0-500 r)

(10) Cutie Pie survey instruments

(11) Portable fast neutron detector

(12) Self reading dosimeters and chargers (0-200 mr; 0-1000 mr; 0-5000 mr)

(13) Film badge

(14) Large area beta-gamma survey instrument used for road surveys

(15) Radiation signs utilized for tagging materials and delineating areas

f. Decontamination

(1) Road

To facilitate surveying large road areas, four Geiger-Muller tubes were mounted in a long tube and attached to the front bumper of a car, Figure II-67. Spots were pinpointed by using an individual survey instrument.

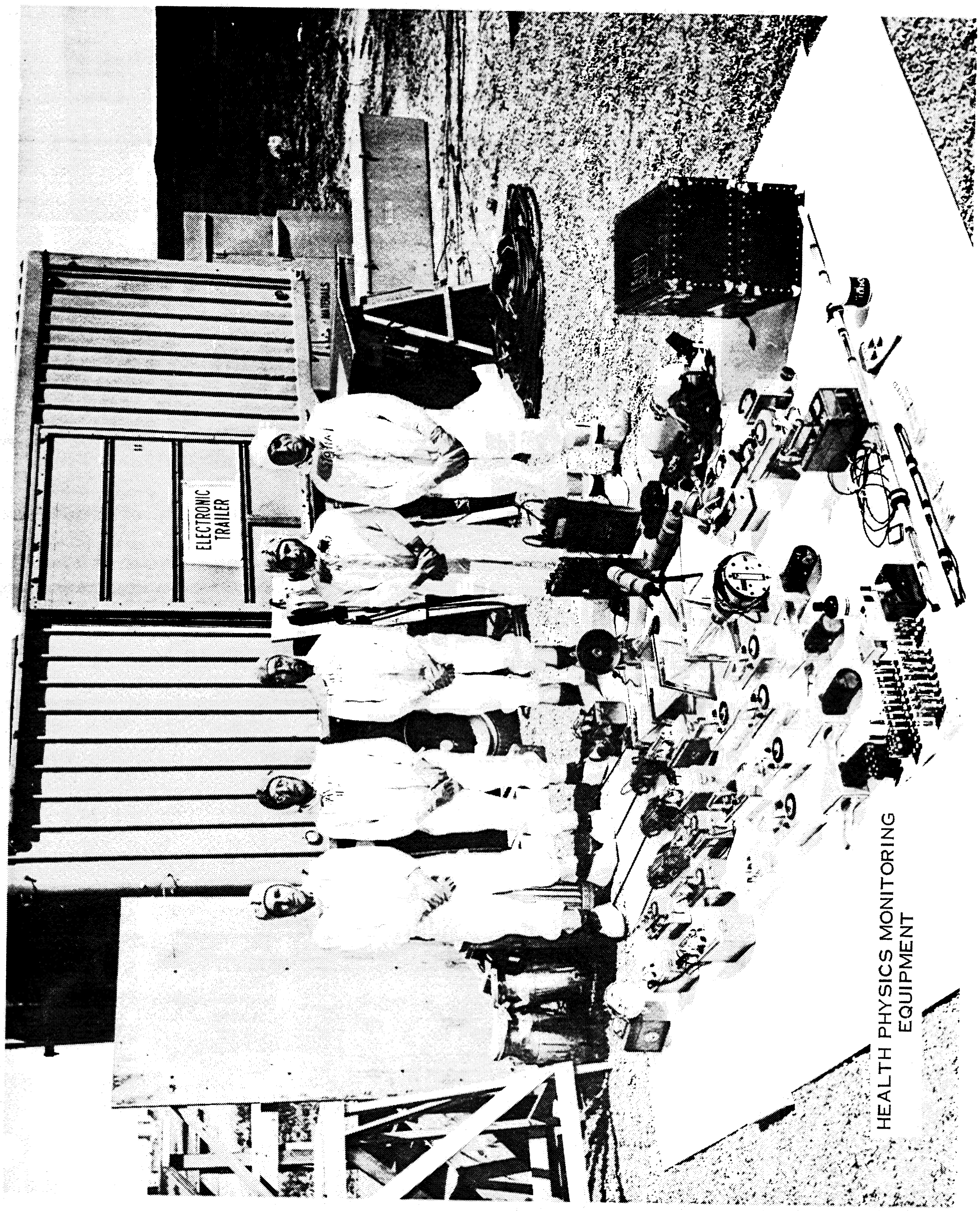


FIGURE II-66

VEHICLE EQUIPPED WITH ROAD
MONITORING EQUIPMENT

FIGURE II-67

The selected methods of road decontamination were tested in order to determine which method or combination of methods would be most effective. A summary of the results is as follows:

(a) Vacuuming was very effective when used in conjunction with abrasive brushes and shipping hammers, for removing fixed contamination

(b) High pressure water and steam were effective for removing gross contamination; however, wet vacuuming was necessary for complete cleaning.

(c) Scrubbing with water and detergents were slow and generally ineffective

(2) Vehicle and Equipment Decontamination

Temporary vehicle and equipment decontamination facilities were established on Fillmore Boulevard between the Control Point and the SL-1 Site. High pressure water and a de-greasing agent were used to decontaminate large vehicles. Turco 2306B powder, citric acid (5% solution), and ammonia were used, when feasible, to clean small pieces of equipment.

Two cranes (10 ton and 35 ton capacities), two $2\frac{1}{2}$ tons flatbed trucks, and six passenger vehicles which were used during recovery operations were cleaned and released. The Austin-Western crane with the shielded cab was cleaned after each entry. Canvas wheel covers were fabricated to eliminate contamination of the tires of the Austin Western crane during final deactivation entries and the need for decontamination after each entry (Figure II-68). Miscellaneous articles (records, files, etc.) were readily cleaned using a dry vacuum cleaner and damp wiping cloths.

A high pressure steam jenny was received in the first week of May. The equipment was mounted on a two wheel trailer and accommodated with a 5,000 gallon make-up water tank truck to make the unit effective for field decontamination (Figure II-69). This unit reduced vehicle and general decontamination requirements greatly.

(3) Personnel Decontamination

Mine Safety Appliance "Fendex" salve has proved to be an effective agent for personnel decontamination. The most effective results were obtained by applying the salve freely with the fingers to the contaminated area and wiping off with clean rags. Usually, only two or three applications were necessary. Personnel with gross contamination were sent to the Chemical Processing Plant at Central Facilities where comprehensive facilities were available.

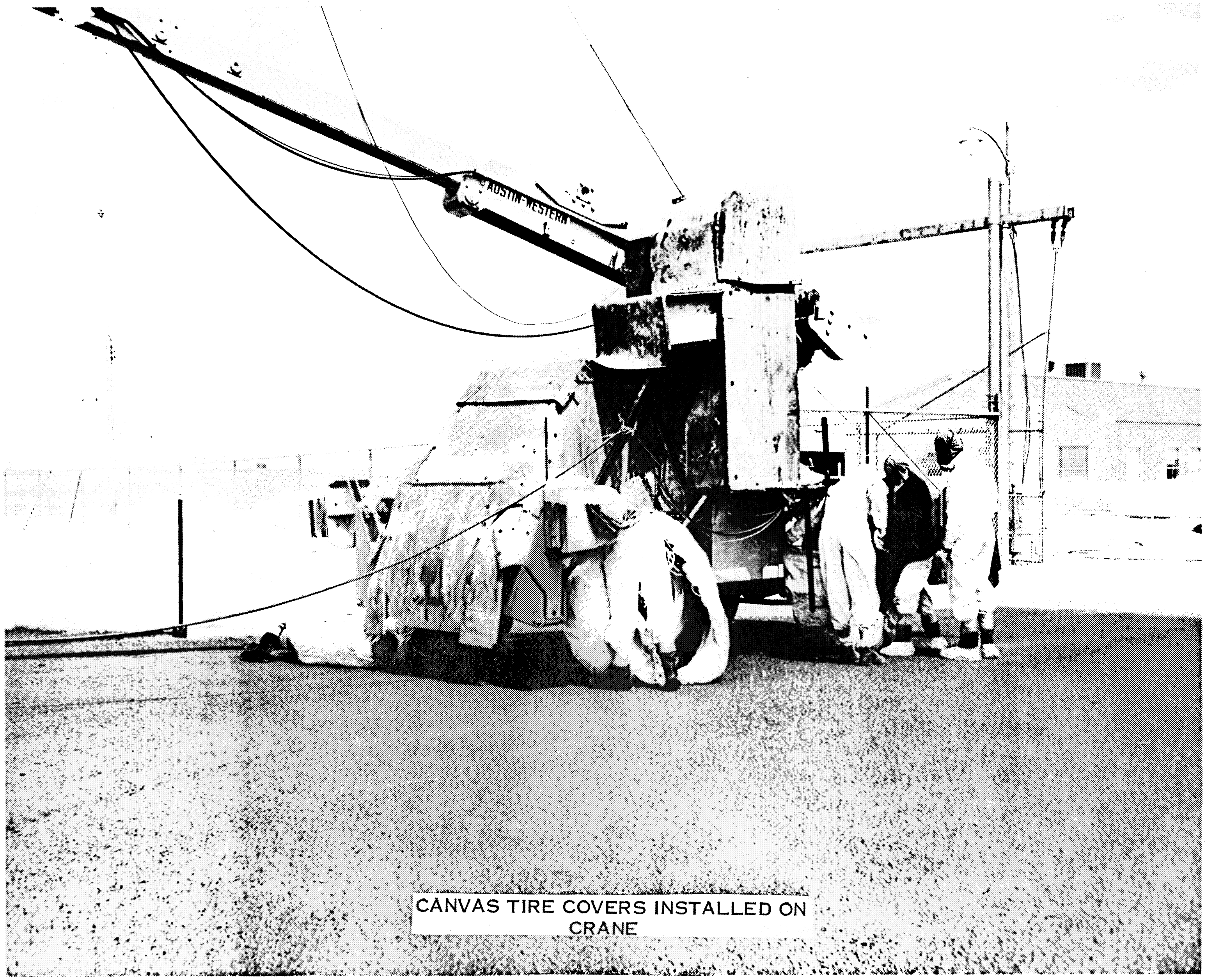
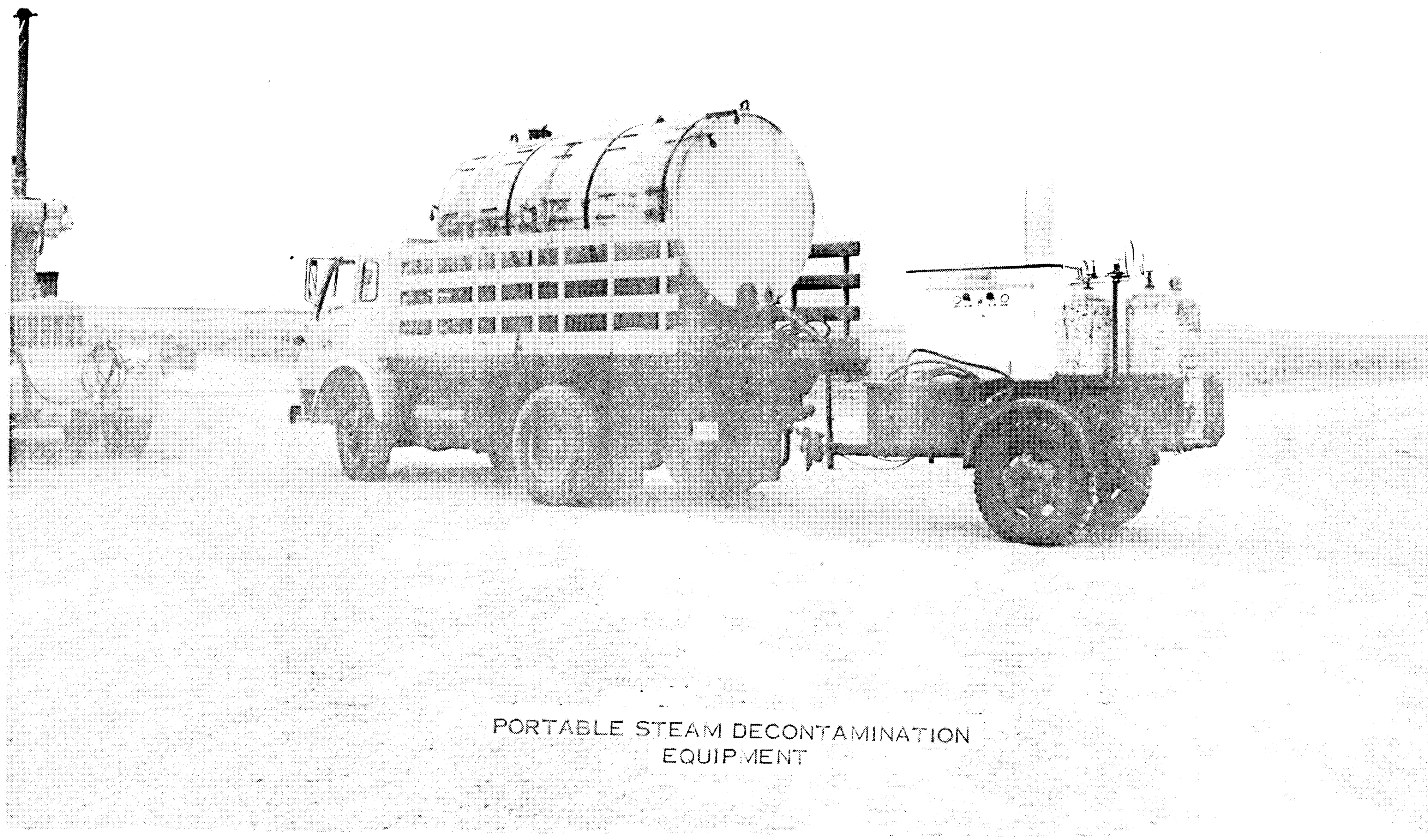


FIGURE II-68



PORTABLE STEAM DECONTAMINATION
EQUIPMENT

FIGURE II-69

H. RADIATION EXPOSURES TO PERSONNEL

1. External Radiation

During the emergency recovery of casualties, 34 individuals received radiation exposures greater than a quarterly dose of 2.5 r. Figure II-70 is a breakdown of personnel exposure levels received.

In January when Combustion Engineering, Inc assumed control of the Health Physics and Safety responsibility of the recovery operations, a personnel exposure limit of 2.5 r per quarter was adopted. During the period from January 16 through May 20 (Date CEI relinquished responsibility for recovery operations) no personnel exposure greater than a rate of 2.5 r /quarter was received (Figure II-71).

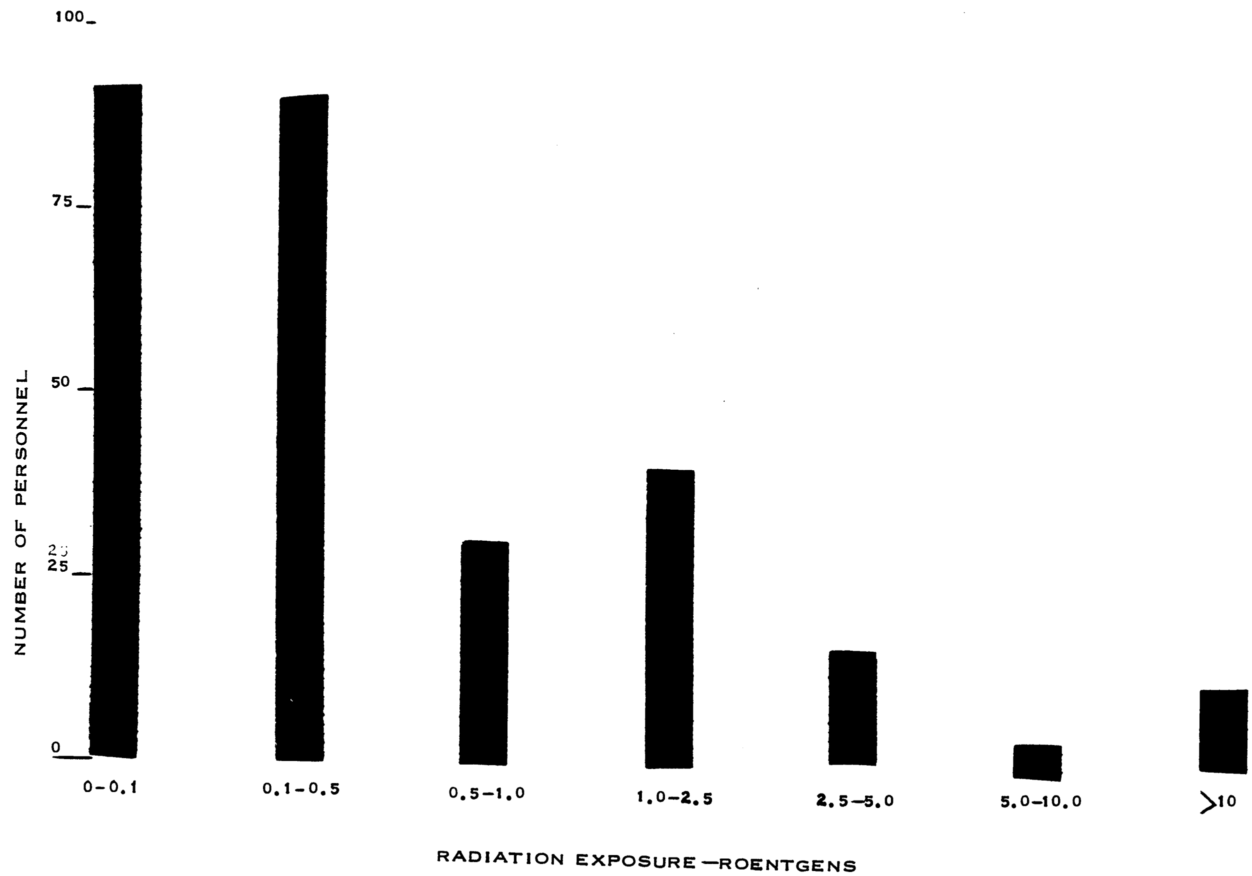
2. Urinalysis Program

a. Emergency Period - Phase I

An urinalysis program was established immediately by the IDO-AEC Site Survey and Medical groups. Specimens were collected after each entry on the following day. Subsequent samples were collected bi-weekly on a routine basis from participating personnel. Follow-up samples on personnel with high exposures were collected daily for the following two weeks. The frequency of sampling was reduced in accordance with decrease in specific activity. The samples were analyzed for gross gamma activity, strontium 90 iodine 131, and cesium 137. Most of the early samples indicates some or all of these nuclides to some degree. Follow-up sampling on personnel with high activity has shown a gradual decrease to levels which are not considered significant.

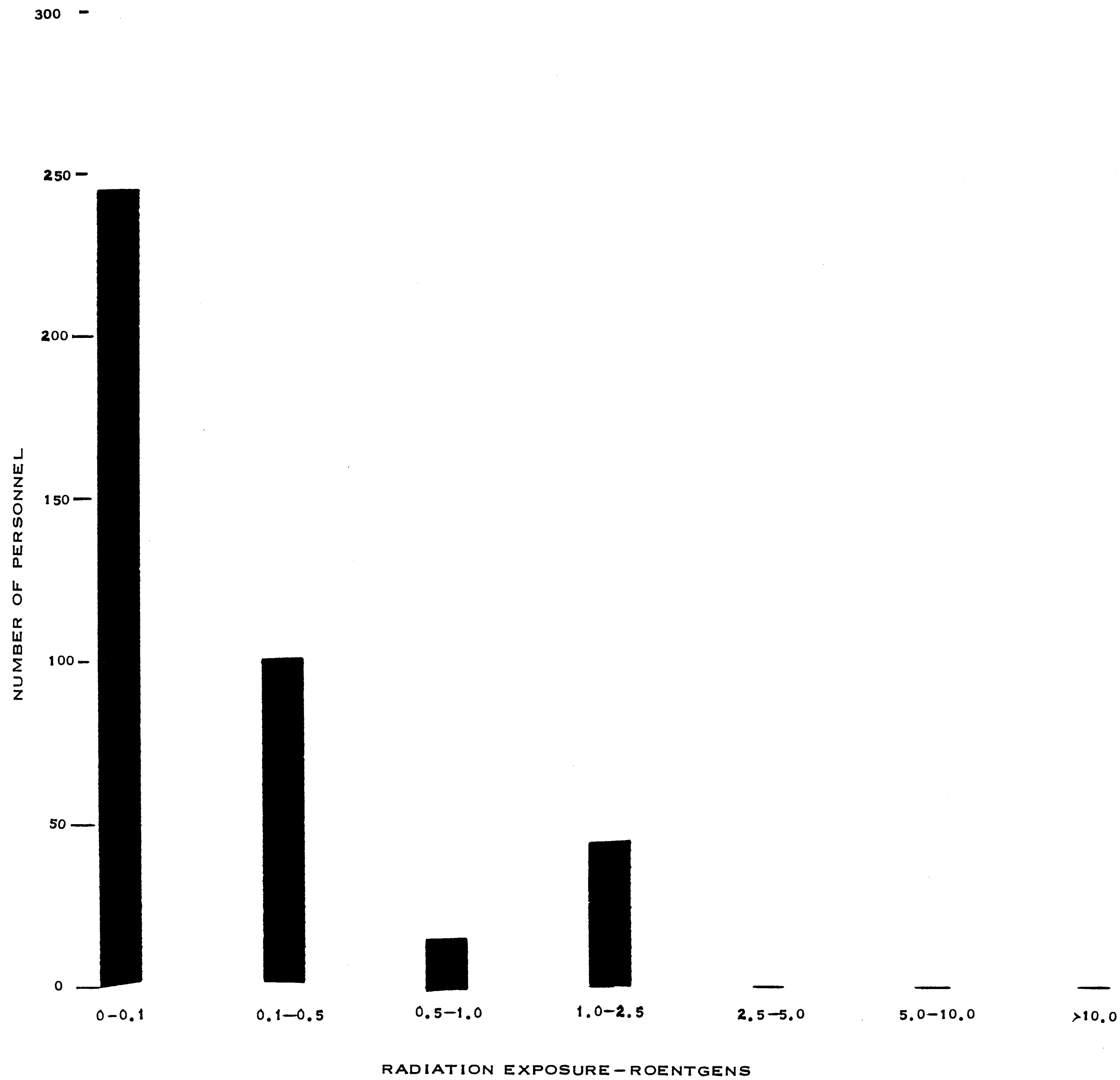
b. Deactivation Period - Phase II

The initial routine urine samples were collected in February on all personnel participating in this phase of the recovery operations. Subsequent samples were analyzed for gross gamma and strontium 90 activity. Analysis of all samples on personnel exposed during this phase revealed negative results.



SL-1 RECOVERY OPERATIONS
PERSONNEL EXPOSURE SUMMARY
JANUARY 3 TO JANUARY 15

FIGURE II-70



SL-1 RECOVERY OPERATIONS

PERSONNEL EXPOSURE SUMMARY
JANUARY 16 TO MAY 20

FIGURE II-71

III PLAN FOR REACTIVITY REDUCTION AND SHIELDING OF SL-1 BY ADDITION OF A POISON SOLUTION

A. BRIEF DESCRIPTION OF PLAN

Combustion submitted a plan on March 28, 1961 for the reactivity reduction and shielding of the SL-1 core. The plan proposed the addition of a 25 gram/liter solution of boric acid to the reactor under the same controlled conditions used in approaching criticality by raising water level in a water moderated core critical experiment. Recognized in the plan were the unknown geometry of the fuel because of observed extensive damage and the lack of information on the existence of water in the vessel.

The addition of the boric acid solution would serve to reduce reactivity for any condition of water level and to provide additional shielding for the core.

Advantages accruing from the operation are:

1. Reduce radiation levels on the operating floor by significantly lowering the direct radiation from the core.

2. If access can be obtained to the top of the SL-1 vessel after deactivation and decontamination, removal of the core in sections should be possible. Examination of these sections may produce valuable information contributing to an understanding of the cause of the SL-1 incident.

3. Placing the SL-1 core beneath a fluid of known chemical composition and behavior and which provides adequate shutdown reactivity probably is a more satisfactory medium long-term disposition of the SL-1 core than its present unknown condition and the finite but remote possibility that accidental water flooding could occur.

4. If possible, insert solid absorbers into the core to lessen the dependence on the absorbing solution.

The method for adding a poison solution would be dependent upon the liquid level in the reactor vessel. Four situations were postulated about the presence or absence of water and level which are as follows:

<u>Case 1</u> - There is no water or very little water in the reactor vessel, and it can be shown by measurement that such is the case.

Case 2 - The water level is below the core and the extent to which it is below the core can be established.

Case 3 - The water level is in the fuel bearing portion of the core and is determined to be so located.

Case 4 - The water level is unknown and continues to remain indeterminable because of the severely damaged condition of the core.

The reactor vessel was subsequently found to be dry; therefore, Case 1 applied. A detailed procedure for the addition of poison solution for Case 1 had not been developed at the time of a Commission decision to adopt a method of dry core removal and examination. A full description of a poisoning plan based upon Case 4 is reported in Reference 9.

B. APPARATUS

1. Equipment List

Figure No.	Drawing No.	Title
III-1	SL1RJ 1020	Poison Injection System Arrangement
III-2	SL1RJ 1023	Poison Injection System Piping Schematic
III-3	SL1RJ 1018	Poison Injection System Electrical Details
III-4	SL1RD 1019	Electrical Control Schematic
III-5	SL1RD 1021	Poison Injection System Control Panel
III-6	SL1RB 1022	Poison Injection System Trailer
III-7	SL1RD 1016	Fission and Ionization Chamber Container Assembly
III-8	SL1RE 1017	Fission and Ionization Chamber Container Details
III-9	SL1RJ 1031	Control Trailer, Nuclear Instrument Drawing
III-10	SL1RB 1037	Alternate End Closure for Fission and Ion Chamber

a. Description of Systems

The poisoning system for adding boric acid solution to the SL-1 reactor vessel was made up of five sections, each of which is described in the following paragraphs.

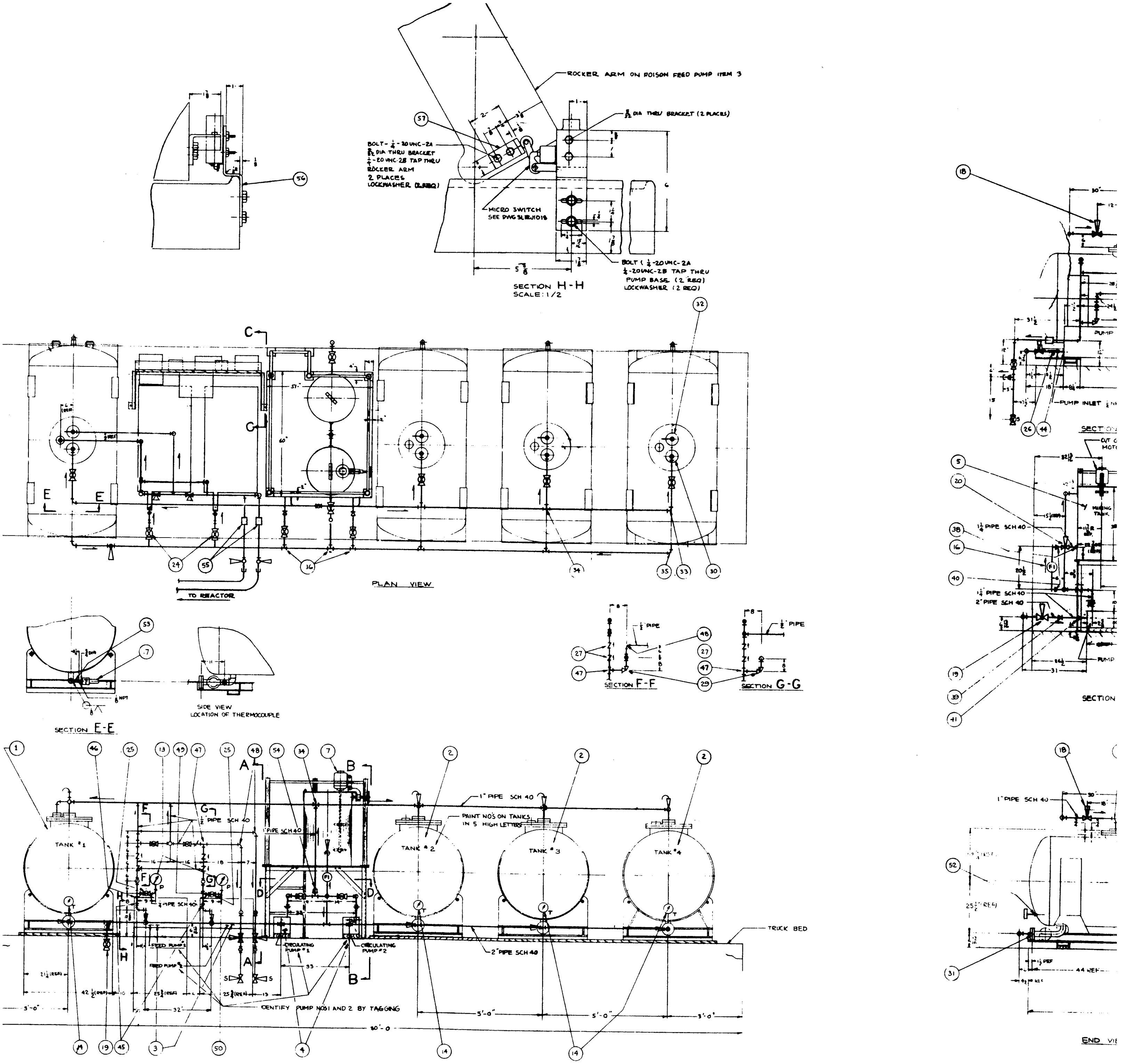
(1) Boric Acid Injection Rig (Figures III-1, III-2)

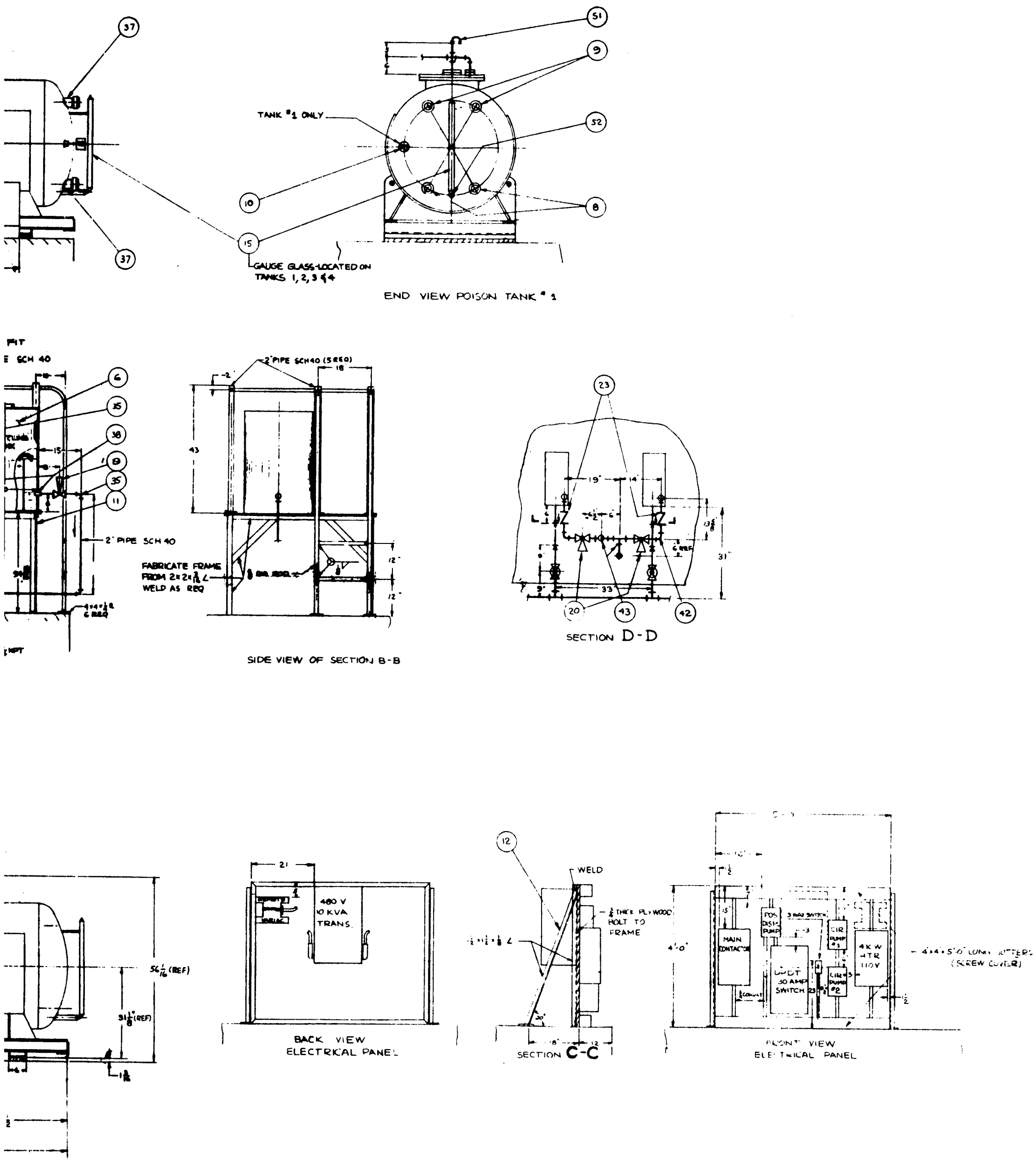
The injection rig consisted of mixing, storage, and injection equipment. The mixing system consisted of two 50 gallon stainless steel drums into which the acid cyrstals would be poured and mixed. These tanks would be piped to the storage section which consisted of four 500 gallon tanks. One of these tanks had a thermostatically controlled immersion heater to hold the solution at desired temperature. Uniform concentration and temperature would be accomplished by means of a circulating pump which constantly circulated the solution through the mixing tanks and storage tanks. The suction to the injection system was taken from the circulating line. It consisted of an injection pump pressure gauge and flow recorder.

Reliability of the system was insured by a second circulating pump system and a second injection system which was installed in parallel. Check valves and pressure relief valves insured against line drainage during poison injection.

A solenoid operated drain valve was included on the discharge side of each injection pump to provide an additional safety precaution to permit instantaneous stopping of the poison injection.

The entire system, which was in contact with the poison, was fabricated of stainless steel.


ROCKER ARM ON POISON FEED PUMP ITEM 3
BOLT - 1/4 - 20 UNC-2A
DIA THRU BRACKET
1/4 - 20 UNC-2B TAP THRU
ROCKER ARM
2 PLACES
LOCKWASHER (2 REQ)
DIA THRU BRACKET (2 PLACES)
MICRO SWITCH
BOLT (1/4 -20 UNC-2A
1/4 -20 UNC-2B TAP THRU
PUMP BASE (2 REQ)
LOCKWASHER (2 REQ)
SECTION H-H
SCALE: 1/2
PLAN VIEW
TO REACTOR
SECTION E-E
SIDE VIEW
LOCATION OF THERMOCOUPLE
SECTION F-F
SECTION G-G
1/2" PIPE
TANK #1
TANK #2
TANK #3
TANK #4
1" PIPE SCH 40
PAINT NO'S ON TANKS IN 5 HIGH LETTERS
2" PIPE SCH 40
FEED PUMPS
CIRCULATING PUMP #1
CIRCULATING PUMP #2
TRUCK BED
IDENTIFY PUMP NOS 1 AND 2 BY TAGGING
MIXING TANK
1 1/4 PIPE SCH 40
2" PIPE SCH 40
PUMP INLET
SECTION
END VIEW



ITEM NO	UNIT	CHARACTERISTICS	MANUFACTURER	MANUFACTURER REF	MAT'L	RE[MARKS]
1	POISON TANK #1	500 GALLON	WESTINGHOUSE	912 F 600	[illegible]	CARBON ST [illegible]
2	POISON TANK # 2, 3 & 4	500 GALLON	WESTINGHOUSE	912 F 600	SAME AS 1	
3	POISON FEED PUMP #1 & #2	18.3 GPH	MILTON ROY	1-85-45-SM		2 H.P., 60 CY, [illegible]
4	POISON CIRCULATING PUMP #1 & 2	20 GPM, 50 PSI				
5	MIXING TANK (WITH COVER)	55 GAL DRUM	Mc MASTER CARR	CATALOG NO 85T	STAINLESS ST.	22 ¾ I.D. [illegible]
6	SETTLING TANK (WITH COVER)	55 GAL DRUM	MC MASTER CARR	CATALOG NO 85T	STAINLESS ST	22 ¾ I.D. [illegible]
7	MIXING TANK STIRRER	1725 RPM ¼ HP 110V	MC MASTER CARR	CATALOG NO 15-3	SEE REMARKS	STAINLESS STEEL CLAMP MOUNTING [illegible]
8	POISON TANK HEATER	2 KW	CHROMALOX	CAT NO MTS-2208	STAINLESS ST. SHEATH	120V SINGLE PHASE
9	POISON TANK HEATER	15 KW	CHROMALOX	CAT NO MTS-2150	STAINLESS ST. SHEATH	440V SINGLE PHA[SE]
10	HEATER THERMOSTATIC CONTROL	ADJUSTABLE RANGE	CHROMALOX	CAT NO AR-2534	STAINLESS S PROTECTIVE WELL	60°F TO 250°F [illegible] STYLE NO [illegible]
11	PLATFORM STRUCTURE (55 GAL DRUM)				CARBON SST	
12	ELECTRICAL PANEL				CARBON SST	
56	SUPPORT BRACKET (MICRO SWITCH)				CARBON SST	
57	BRACKET-MICRO SWITCH ACTUATOR				CARBON SST	

INSTRUMENT LIST

ITEM NO	INSTRUMENT NAME	MANUFACTURE NAME	MANUFACTURE CAT' NO	NO REQ	CHARACTERISTICS
13	PRESSURE GAUGE	ASHCROFT	1379S	2	0 - 200 PSIG RANGE
14	POISON TANK TEMPERATURE GAUGE	WESTON		4	0-250°F RANGE 2°F INCREMENTS 5 DIA CASE ANGLE FORM ½ INCH DIAM SHANK SIZE
15	POISON TANK LIQUID LEVEL GAUGE	Mc MASTER CARR	37N003	4	½ INCH DIAM GLASS SIZE
16	MIXING TANK INLET FLOWMETER	FISHER & PORTER CO.	MODEL #10A2735P	1	STANDARD ACCURACY 2% MAX FLOW 10" DIRECT READING SCALE
17	POISON TANK #1 THERMOCOUPLE	CONAX CORP.	SPW-MK3B-24-CC-H	1	0-400°F RANGE STAINLESS ST. WELL 6" LONG
55	DISCHARGE PUMP FLOW INDICATOR			1	

VALVE AND SPECIAL FITTINGS LIST

ITEM NO	SERVICE	TYPE	NOM SIZE	END CONN	MANUFACTURE NAME	MANUFACTURE CAT' NO	MAT'L	NO REQ
18	POISON TANK FILL	GATE	1 INCH	FEMALE			STAINLESS ST	4
19	POISON TANK DRAIN VALVE CIRCULATING PUMP SUCTION SETTLING TANK DISCHARGE	GATE	2 INCH	FEMALE				4
20	CIRCULATING PUMP DISCHARGE MIXING TANK INLET	GLOBE	1½ INCH	FEMALE				3
23	CIRCULATING PUMP DISCHARGE	SWING CHECK	1½ INCH	FEMALE				2
24	POSITIVE DISPL PUMP SUCTION PUMP BY PASS PUMP DISCHARGE	GATE	½ INCH	FEMALE				6
25	PRESSURE GAUGE SHUT-OFF	GATE	¼ INCH	FEMALE				2
26	PUMP SUCTION STRAINER	STRAINER	½ INCH	FEMALE				2
27	POSITIVE DISPL PUMP DISCHARGE	SWING CHECK	½ INCH	FEMALE				4
28	SOLENOID DRAIN VALVE	SOLENOID VALVE	½ INCH	FEMALE				2
29	POSITIVE DISPL PUMP RELIEF VALVE	RELIEF VALVE	½ INCH	FEMALE				2

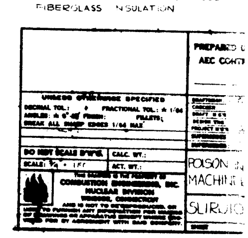
FITTING LIST

ITEM NO	SERVICE	TYPE	NOM SIZE	END CONN.	MANUFACTURE NAME	MANUFACTURE CAT' NO	MAT'L	NO REQ
30	POISON TANK FILL	BLIND FLANGE	2" PIPE	—			STAINLESS ST	4
31	POISON TANK DRAIN	BLIND FLANGE	2" PIPE	—				4
32	POISON TANK VENT	BLIND FLANGE	1" PIPE	THREAD FEMALE				4
33	POISON TANK FILL	90° ELBOW	1" PIPE					6
34	POISON TANK FILL	TEE	1" PIPE					3
35	POISON TANK DRAIN SETTLING TANK DISCHARGE MIXING TANK DISCHARGE	90° ELBOW	2" PIPE					6
36	POISON TANK DRAIN CIRCULATING PUMP SUCTION	TEE	2" PIPE					5
37	POISON TANK # 1, 2, 3, 4 (HEATER CONN) MIXING TANK & SETTLING TANK	HALF COUPLING	2" PIPE					19
38	MIXING TANK SUCTION	HALF COUPLING	1½ PIPE					1
39	CIRCULATING PUMP SUCTION	REDUCER	2" TO 1½" PIPE					2
40	FLOW INDICATOR	HEX BUSHING	2" TO 1½ PIPE					2
41	CIRCULATING PUMP	UNION	1½ PIPE					4
42	CIRCULATING PUMP DISCHARGE	90° ELBOW	1½ PIPE					4
43	" " "	TEE	1½ PIPE					2
44	POSITIVE DISPLACEMENT PUMP INLET	UNION	½ PIPE					2
45	" " DISCHARGE	UNION	½ PIPE					2
46	" "	HEX BUSHING	½ TO ¼ PIPE					2
47	" "	TEE	½ PIPE					10
48	" "	90° ELBOW	½ PIPE					14
49	PRESSURE INDICATOR INLET	HEX BUSHING	½ TO ¼ PIPE					2
50	" "	90° ELBOW	¼ PIPE					2
51	AIR VENT POISON TANK	RETURN BEND	½" PIPE					4
52	TEMP GAUGE CONN & GAUGE GLASS CONN	HALF COUPLING	½" PIPE					9
53	THERMOCOUPLE CONNECTOR	¼ D ROD						1
54	CIRCULATING PUMP BYPASS	HEX BUSHING	½ TO ¼ PIPE					

PIPING LIST

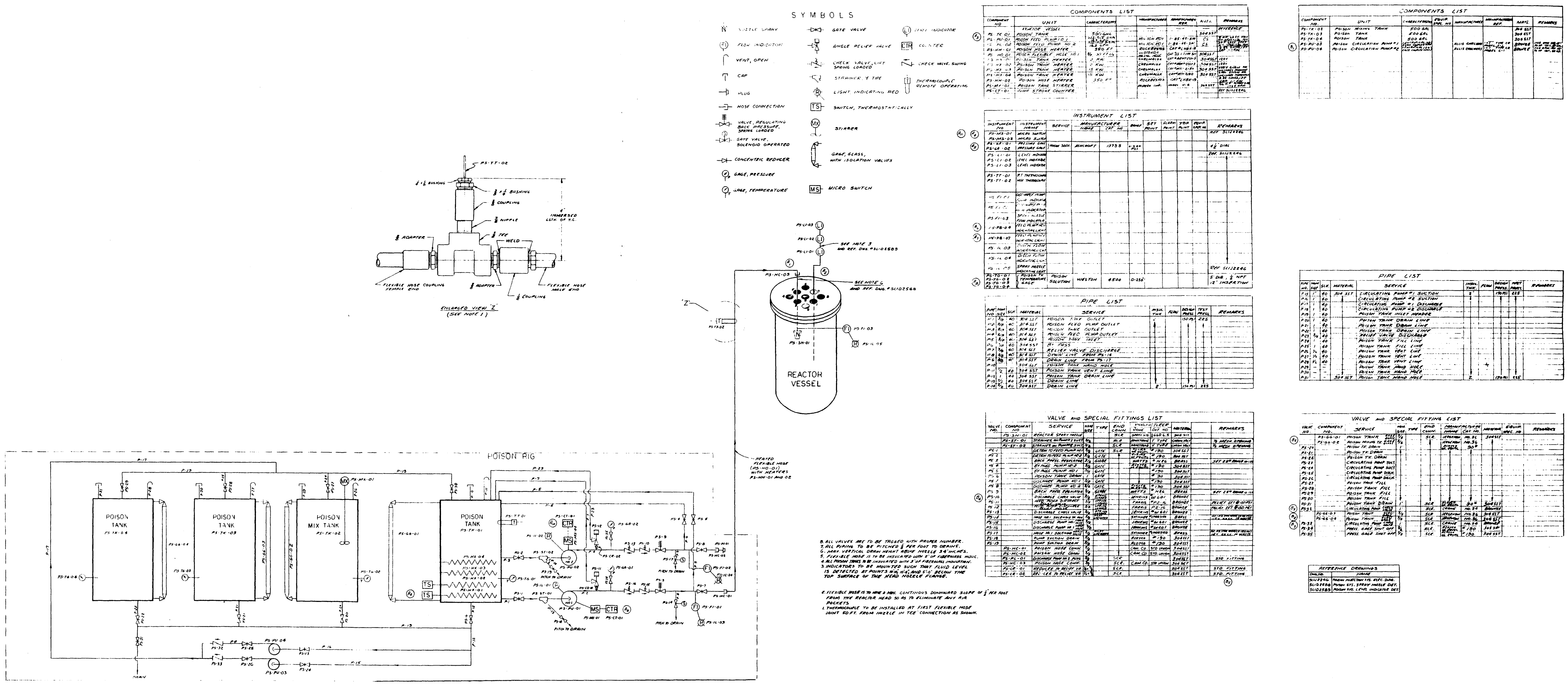
NOM SIZE	SCH	TOTAL FT REQ	DESIGN PRESS	TEST PRESS	MAT'L
½"	40	60	150	225	304 SST
1"		60			
1½"		15			
2"		60			

2- ALL PIPING TO BE INSULATED WITH FIBERGLASS INSULATION
1- ALL POISON TANKS TO BE INSULATED [WITH] FIBERGLASS INSULATION



POISON INJECTION SYSTEM MACHINERY ARRANGEMENT

FIGURE III-1



POISON INJECTION SYSTEM PIPING SCHEMATIC

Fig. III – 2

(2) Process Instrument and Control System (Figures III-3, III-4)

The electrical systems consisted of instrumentation for poison temperature measuring and control, injection pump flow, poison line temperature and flow, emergency drain valve, energizing, and water level indicating. The power to operate these systems came from an existing 440 volt AC power station at the control area. The power originated from a 300 KVA transformer at the PL condenser building breaker. Multiple connectors were to be used to connect the poison rig and control center to multi-connector cables allowing transmission of signals over a distance of 5,000 feet.

(3) Control Center (Figures III-5, III-6)

The control center consisted of a trailer which housed a panel containing all the controls and indicating and recording instruments. The operating and maintenance areas were to be separated by the panel thus requiring exit from the trailer in order to move from one area to the other. This was intended to prevent accidental contacting of instruments or electrical equipment during operations. Space was provided for a desk for the operators in front of the control panel. An observation section behind the operations desk completed the control area. Air conditioning of the instrument panel was planned.

(4) Nuclear Instrumentation (Figures III-7, III-8, III-9, III-10)

The nuclear instrumentation consisted of four separate channels to receive signals from four fission chambers. Each signal required preamplification and linear amplification to be located in the SL-1 administration building.

Regulated voltage to these systems was to be supplied. Since there is no system ground in this location, the equipment would not be mounted. Interconnecting coaxial cable would transmit the signal from each channel to receiving stations located in the control center.

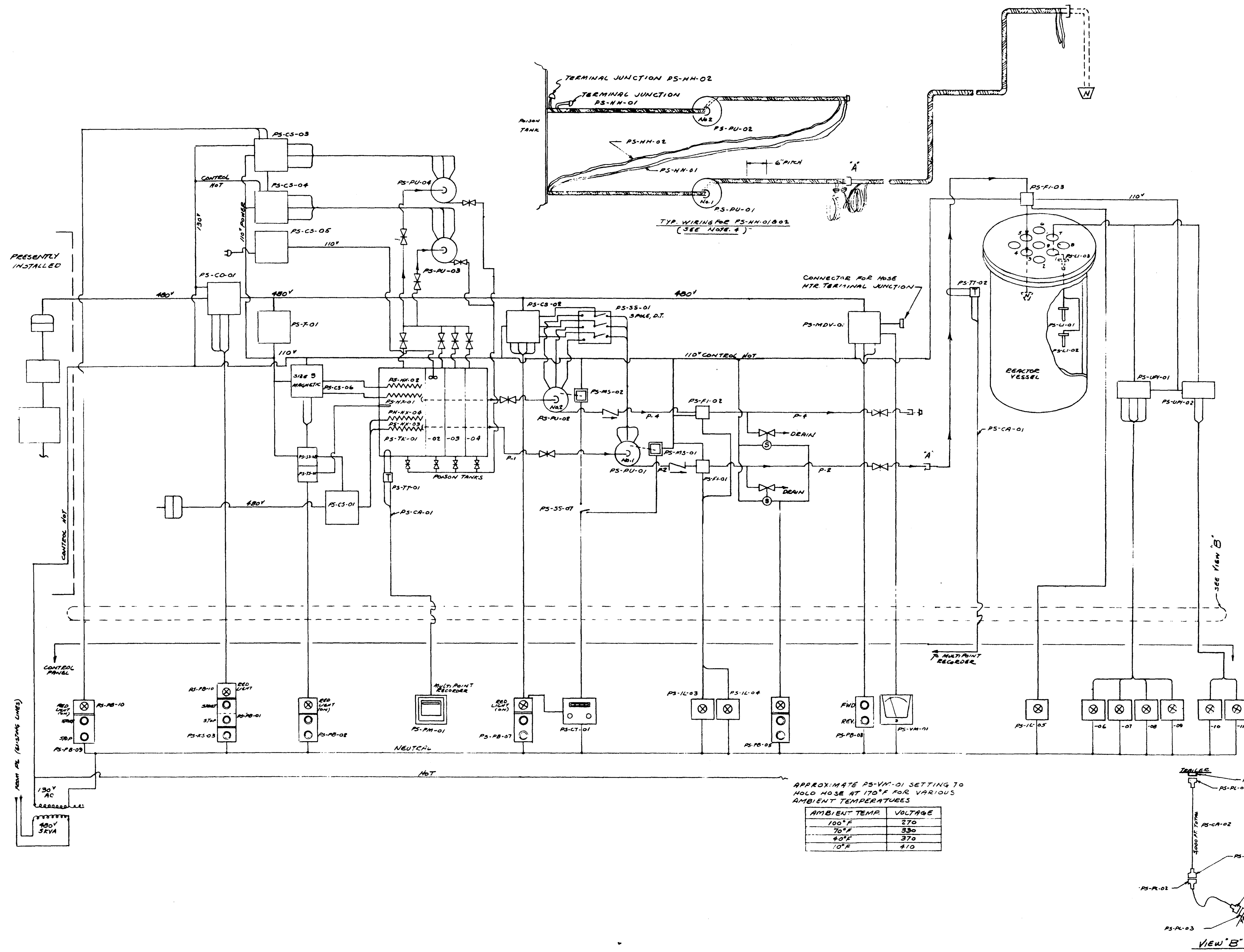
(5) Remote Poisoning Systems

The remote poisoning systems were divided into two parts based on the two entries required to poison each system.

(a) Poison spray nozzle and sonic probe system

(b) Nuclear instrumentation system

The poison spray nozzle and sonic probe system would be supported on the Austin-Western movable crane boom. Quick disconnect fittings would permit connection between poison rig and flexible hose. Electrical connections for the instrumentation also were of the quick disconnect type.



APPROXIMATE PS-VM-01 SETTING TO HOLD HOSE AT 170°F FOR VARIOUS AMBIENT TEMPERATURES

AMBIENT TEMP.	VOLTAGE
100°F	270
70°F	330
40°F	370
10°F	410

INST. NO.	DESCRIPTION	MANUFACTURER NAME	MANUFACTURER MODEL NO.	RANGE	RATING	TRIP POINT		REMARKS
PS-CO-01	CONTACTOR	SQ D	8502 DG-2		[illegible]			NEMA 1 ENCL. WITH INTERLOCK
PS-T-01	TRANSFORMER	G.E.	9T-36M		[illegible] QUIET TYPE 10 KVA			2-2½% TAPS ABOVE & BELOW NORMAL
PS-CS-06	COMB. STARTER	SQ D	8538 CG-3		[illegible] 110 V COIL	C.B. 60-A	SIZE 3	NEMA 1 ENCL. WITH INTERLOCK
PS-SS-07	SELECTOR SWITCH	BRYANT	4803		3 WAY SWITCH	15A		[illegible] SHEET METAL COVER
PS-LI-03	ULTRASONIC PROBE	POWERTRON	UP1004		[illegible]			
PS-TT-01	THERMOCOUPLE	THERMOELECTRIC	[illegible] OR EQUAL	0-400 °F	TYPE T, [illegible] IN. INSERTION, SS WELL 1 IN. NPT CONN.			[illegible] INCH EXTENSION UNIVERSAL HEAD
PS-SS-01	SAFETY SWITCH	SQ. D	82341F		[illegible]			NEMA 1 ENCL.
PS-CS-02	COMB. STARTER	SQ. D	8538 SG-2		[illegible]	C.B. -15A		NEMA 1 ENCL.
PS-MS-01	MICRO SWITCH	MPLS. HONEY			110 V 10 A			
PS-MS-02	MICRO SWITCH	MPLS. HONEY			110 V 10 A			
PS-FI-01	FLOW SWITCH	GEM			AC-[illegible] V, 10 W MAX.			
PS-FI-02	FLOW SWITCH	GEM			AC-[illegible] V, 10 W MAX.			
PS-MDV-01	VARIAC MOT. DRIVEN	SUPERIOR, OR EQUAL			[illegible]			NEMA 1 ENCL.
PS-TT-02	THERMOCOUPLE	THERMOELECTRIC	5DO231P, OR EQUAL		TYPE T, [illegible] IN. INSERTION, SS JACKET [illegible] IN. NPT NIPPLE			3J89S COUPLING
PS-FI-03	FLOW SWITCH	GEM						
PS-LI-01	ULTRASONIC PROBE	POWERTRON	UP1004		[illegible]			
PS-LI-02	ULTRASONIC PROBE	POWERTRON	UP1004		[illegible]			
PS-UPI-01	US. PROBE IND.	POWERTRON	UC1010					
PS-IL-03	PUSH TO TEST	G.E. OR EQUAL	CR-104D522		[illegible] INCANDESCENT LAMP, OR EQUAL			PUSH TO TEST UNIT
PS-IL-04	↕	↕	CR-104D522		↕			↕
PS-IL-05			CR-104D522					
PS-IL-06			CR-104D522					
PS-IL-07			CR-104D322					
PS-IL-08			CR-104D322					
PS-IL-09	PUSH TO TEST	G.E. OR EQUAL	CR-104D522		[illegible] INCANDESCENT LAMP, OR EQUAL			PUSH TO TEST UNIT
PS-PB-01	P.B. CONTROL STA.	SQUARE D	TM-1		TYPE TB [illegible] (START) TYPE TB [illegible] (STOP)			
PS-PB-02	P.B. CONTROL STA.	SQUARE D	TM-1		(MAINTAINED CONTACT) 2-TYPE TB OPERATORS AND 1 TYPE TB CONTACT BLOCK			
PS-KS-03	KEY SWITCH	SQ. D OR EQUAL			[illegible]			
PS-PB-05	P.B. CONTROL STA.	SQ. D	CR-[illegible] AA [illegible]		SEE PS-PB-02			
PS-PB-07	P.B. CONTROL STA.	SQ. D	TM-1		SEE PS-PB-02			
PS-CA-01	TO EXT. WIRE	THERMOELECTRIC	PP14D [illegible]		[illegible] GA. COPPER-CONSTANTAN DOUBLE POLYVINYL JACKET			2 REQUIRED
PS-CTR-01	COUNTER	VEEDER-ROOT	1601		[illegible] CPM, 115 V AC, [illegible] A CONTACTS			
PS-VM-01	VOLTMETER	INTERNATIONAL [illegible]	1147, OR EQUAL		0-500 V AC			WEATHERPROOF
PS-PM-01	POTENTIOMETER	M.H. RECORDER	MULTIPOINT		0-300 °F			
PS-PB-08	P.B. CONTROL STA.	SQ. D	TYPE TRIS		1 EA. FORWARD, 1 EA. REVERSE			
PS-CS-03	COMB. STARTER	SQ. D	[illegible]		[illegible] V, 1 φ, [illegible], SIZE 0, 110V COIL	C.B. 15A		NEMA 1 ENCLOSURE WITH ON-OFF BUT. AND INTERLOCK
PS-CS-04	COMB. STARTER	SQ. D	[illegible]		[illegible] V, 1 φ, [illegible], SIZE 0, 110V COIL	C.B. 15A		NEMA 1 ENCLOSURE WITH ON-OFF BUT. AND INTERLOCK
PS-CS-05	COMB. STARTER	SQ. D	[illegible]		[illegible] V, 1 φ, [illegible], SIZE 0, 110V COIL	C.B. 15A		NEMA 1 ENCLOSURE WITH ON-OFF BUT. AND INTERLOCK
PS-PB-09	P.B. CONTROL STA.	G.E.	CR [illegible] AA [illegible]		SEE PS-PB-02			
PS-PB-10	PUSH TO TEST PILOT LIGHTS	SQ. D OR EQUAL						
PS-JA-01	CONNECTOR-JACK	CANNON ELEC	MS-[illegible]		[illegible] A. MIN., [illegible] VOLT DROP MAX.			36 PIN WEATHERPROOF
PS-PL-01	CONNECTOR-PLUG	↕	MS-[illegible]		↕			↕
PS-JA-02	CONNECTOR-JACK		MS-[illegible]					
PS-PL-02	CONNECTOR-PLUG		MS-[illegible]					
PS-JA-03	CONNECTOR-JACK		MS [illegible]	FLUSH MOUNT				
PS-PL-03	CONNECTOR-PLUG	CANNON ELEC	MS [illegible]	FLUSH MOUNT	[illegible] A. MIN., [illegible] VOLT DROP MAX.			36 PIN WEATHERPROOF
PS-CA-02	CABLE, CONTROL	TRIANGLE	[illegible] 12 COND.	OR EQUAL				RUBBER INSULATED [illegible]
PS-IL-10	IG. LIGHT	G.E.	CR-104D522		[illegible] INCANDESCENT LAMP, OR EQUAL			PUSH TO TEST UNIT [illegible]
PS-IL-11	IG. LIGHT	G.E.	CR-104D522		[illegible] INCANDESCENT LAMP, OR EQUAL			PUSH TO TEST UNIT [illegible]
PS-UPI-02	US PROBE IND.	POWERTRON	UC1010					
PS-TK-01	POISON TANK							REF. DWG. SL1RJ1020
PS-TK-02	POISON TANK							REF. DWG. SL1
PS-TK-03	POISON TANK							REF. DWG. SL1
PS-TK-04	POISON TANK							REF. DWG. SL1
PS-PU-01	POISON FEED PUMP							REF. DWG. SL1
PS-PU-02	POISON FEED PUMP							REF. DWG. SL1
PS-PU-03	POISON CIRC. PUMP							REF. DWG. SL1
PS-PU-04	POISON CIRC. PUMP							REF. DWG. SL1
PS-HX-01	POISON TK. HTR.							REF. DWG. SL1
PS-HX-02	POISON TK. HTR.							REF. DWG. SL1
PS-HX-03	POISON TK. HTR.							REF. DWG. SL1
PS-HX-04	POISON TK. HTR.							REF. DWG. SL1RJ1020
PS-HH-01	POISON HOSE HTR.	ROCKBESTOS	CAT. [illegible]		[illegible] OHMS FT., CAP. 1.1 KW			350 FEET
PS-HH-02	POISON HOSE HTR.	ROCKBESTOS	CAT. [illegible]		[illegible] OHMS FT., CAP. 1.1 KW			350 FEET
PS-CS-01	COMB. STARTER	SQ. D	SIZE 3		440V, 110V CONTROL			
PS-TS-01	THERMOSTAT	CHROMOLOX	TYPE AR STYLE No. 4	ADJUSTABLE	50° TO 250°F, 3⅛ INCH BULB			CAT. No. AR-2534
PS-SS-08	SELECTOR SWITCH	SAME	AS	PS-SS-	07			

NOTES -
1. MOUNT ALL REMOTE CONTROLS AND READOUTS ON PANEL IN TRAILERS.
2. ORDER EXTRA CONTACTS FOR CONTACTOR & STARTERS IN KIT FORM & FIELD ASSEMBLE.
3. ALL POWER LEADS TO BE RUN THROUGH MULTIPIN CONNECTORS AND MULTICONNECTORS CABLES AS SHOWN IN B.
4. RESISTANCE HEATING WIRE (PS-HH-01) FOR FLEXIBLE HOSE IS TO BE DOUBLED AND SPIRAL WOUND ON A SIX INCH PITCH FOR THE ENTIRE LENGTH OF HOSE. LOOP AT POINT A FOR AT LEAST 3 FT. & CONTINUE SPIRAL WOUND ON PIPING P-1 THRU P-4 & PS-HH-02 IS SIMILARLY WOUND. DO NOT CROSS WIRES.
5. POWER WIRING AND CONNECTORS NOT DESIGNATED BY NUMBERS ARE STANDARD ELECTRICAL UNITS AVAILABLE AT CF SHOPS.
6. ALL INDICATOR LIGHTS ARE PUSH TO TEST TYPE, SAME AS PB-10.
7. TWO 4 IN. X 4 IN. X 8 FT. GUTTERS, SCREW COVER STANDARD (NO K.O.)
8. TERMINAL BLOCKS, NUMBER AND SIZE TO BE SPECIFIED TO AVAILABILITY.
9. MISCELLANEOUS - CONDUIT, LOCK-NUTS, & BUSHINGS, ETC. 50% AVAILABLE IN SURPLUS.

PREPARED UNDER AEC CONTRACT AT(10-1)967

UNLESS OTHERWISE SPECIFIED
DECIMAL TOL.: FRACTIONAL TOL.: ± 1/64
ANGLES: ± 0°-30' FINISH: FILLETS:
BREAK ALL SHARP EDGES 1/64 MAX.

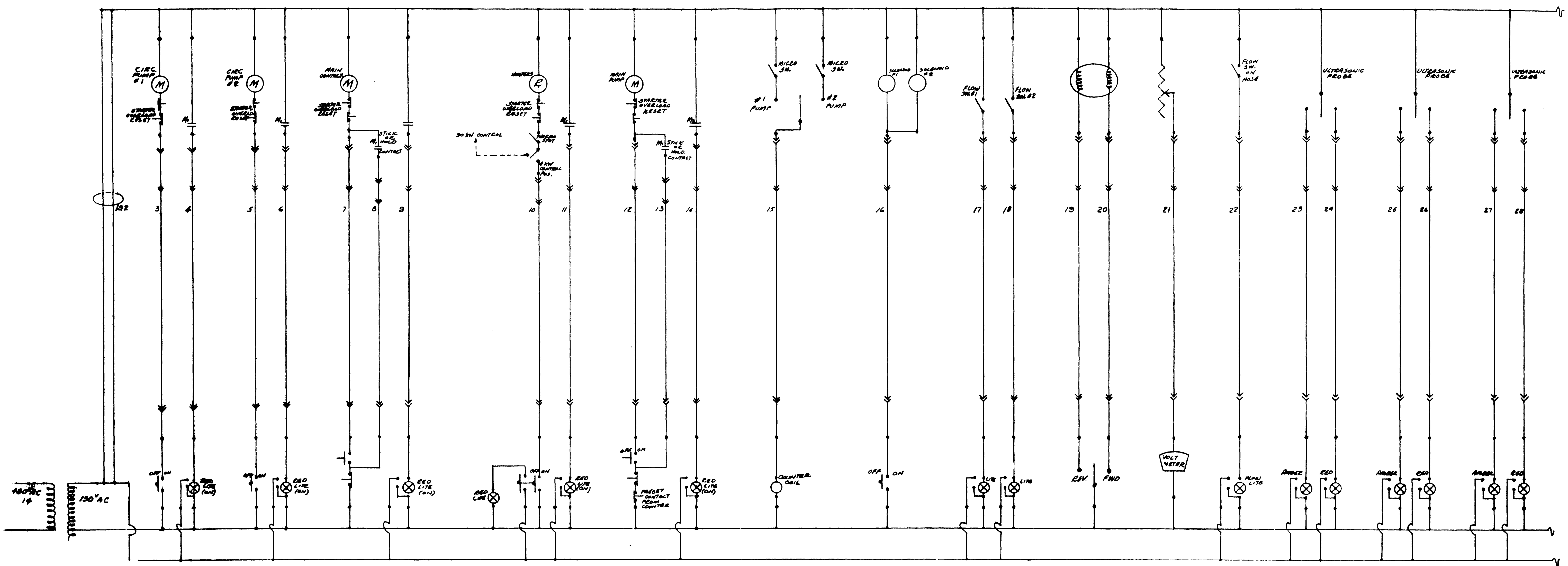
DO NOT SCALE DWG. CALC. WT.:
SCALE: ACT. WT.:

POISON INJECTION SYSTEM ELECTRICAL DIAGRAM

SL1RJ 1018

POISON INJECTION SYSTEM ELECTRICAL DIAGRAM

FIGURE III-3



ELECTRICAL CONTROL SCHEMATIC

FIGURE III-4

	PREPARED UNDER AEC CONTRACT AT(10-1)961	CEND CONTRACT 15458-3
UNLESS OTHERWISE SPECIFIED DECIMAL TOL.: FRACTIONAL TOL.: ± 1/64 ANGLES: ± 0°-30 FINISH: FILLETS: BREAK ALL SHARP EDGES 1/64 MAX.	DRAFTSMAN: RG 4/14/61 CHECKER: DRAFT M'G'R DESIGN ENG PROJECT M'G'R SUPERSEDES: SUPERSEDED BY:	
DO NOT SCALE D'W'G. / CALC. WT.: SCALE: / ACT. WT.:	ELECTRICAL CONTROL SCHEMATIC POISON RIG)	
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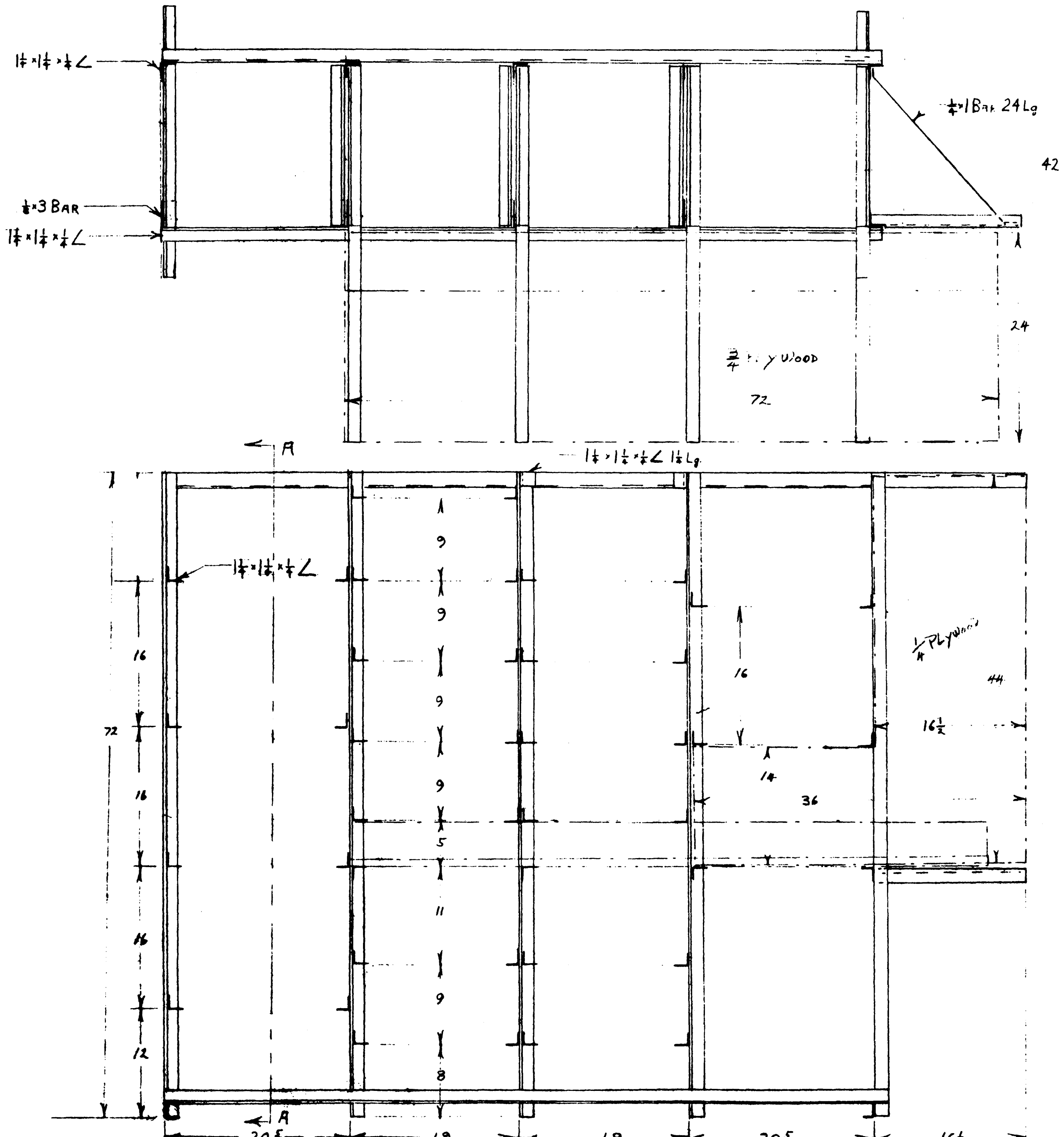
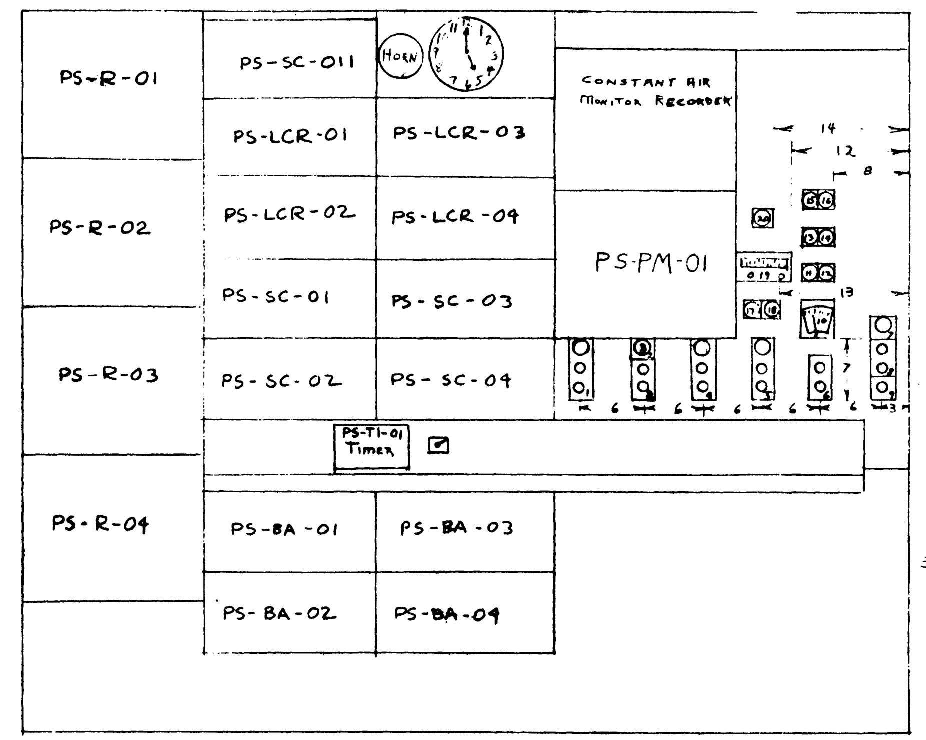
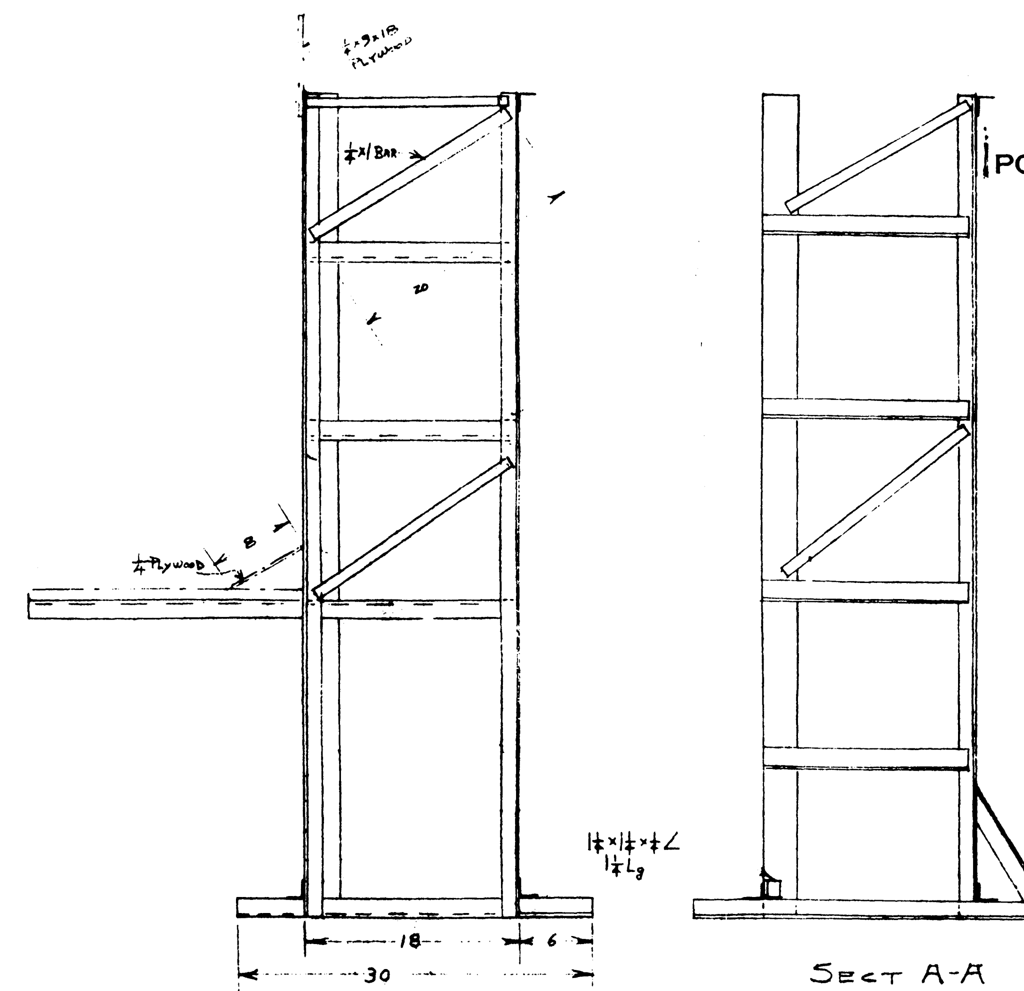






Bill of Material

	Item		Qty
1	1¼ × 1¼ × ¼ ∠	16 Long	2
2	"	1¼ "	6
3	"	18 "	38
4	"	42 "	4
5	"	30 "	2
6	"	72 "	6
7	"	80½ "	3
8	[illegible] × 3 Plate	72 "	4
9	¼ × 1 Bar	24 "	2
10	"	20 "	9
11	¾ × 24 × 72 Plywood		1
12	¼ × 36 × 44 "		1
13	¼ × 8 × 72 "		1
14	¼ × 9 × 18 "		1
15	Electric Timer		1
16	9" Dia Electric Clock		1

Index of Controls

Item No	Bill of Material No. Ref. SLIR-J1018
1	PS-PB-05
2	PS-PB-09
3	PS-PB-10
4	PS-PB-02
5	PS-PB-07
6	PS-PB-08
7	PS-PB-10
8	PS-PB-01
9	PS-KS-03
10	PS-VM-01
11	PS-IL-06
12	PS-IL-07
13	PS-IL-08
14	PS-IL-09
15	PS-IL-10
16	PS-IL-11
17	PS-IL-03
18	PS-IL-04
19	PS-CT-01
20	PS-IL-05

Notes

1. Fabricate the five vertical section by fillet welding. Assemble by bolting 80½ long ∠s to the vertical sections
2. Bolt plywood control panel and desk sections to ∠ frame.
3. Cut panel as necessary to mount controls as shown.

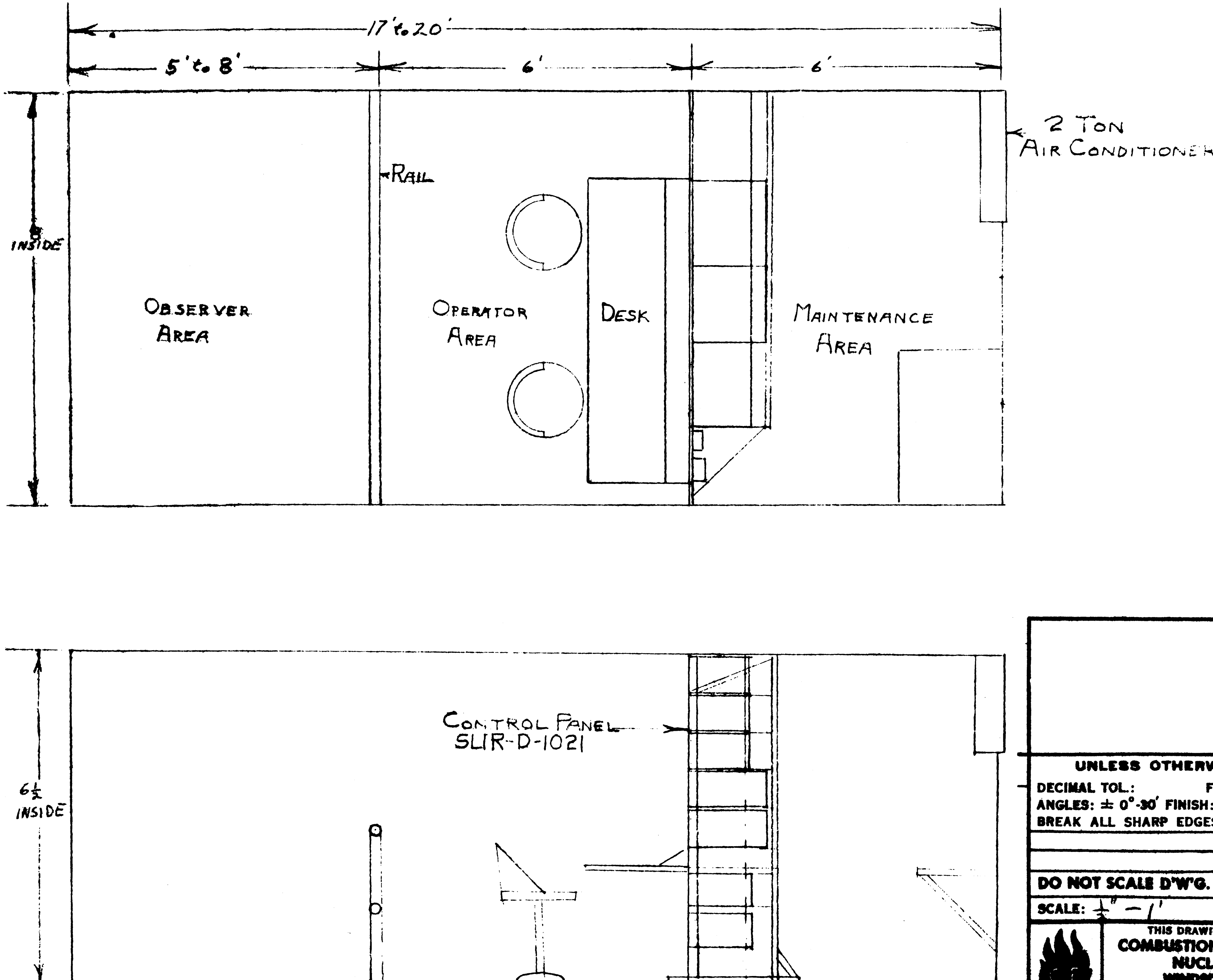
POISON INJECTION SYSTEM CONTROL PANEL

FIGURE III-5

Prepared under AEC Contract — CEND Contract

Poison Injection System Control Panel

SLIR-D-1021



Notes:
1. Separate doors to Observer and Maintenance areas are required.

POISON INJECTION SYSTEM

TRAILER

FIGURE III-6

	PREPARED UNDER AEC CONTRACT	CEND CONTRACT
UNLESS OTHERWISE SPECIFIED DECIMAL TOL.: FRACTIONAL TOL.: ± 1/64 ANGLES: ± 0°-30' FINISH: FILLETS: BREAK ALL SHARP EDGES 1/64 MAX.	DRAFTSMAN CHECKER: DRAFT. M'G'R. DESIGN ENG. PROJECT M'G'R.	DATE 4/1/61
	SUPERSEDES:	
	SUPERSEDED:	
DO NOT SCALE D'W'G. CALC. WT.: SCALE: 1/4" — 1' ACT. WT.:	Poison Injection System Control Trailer	
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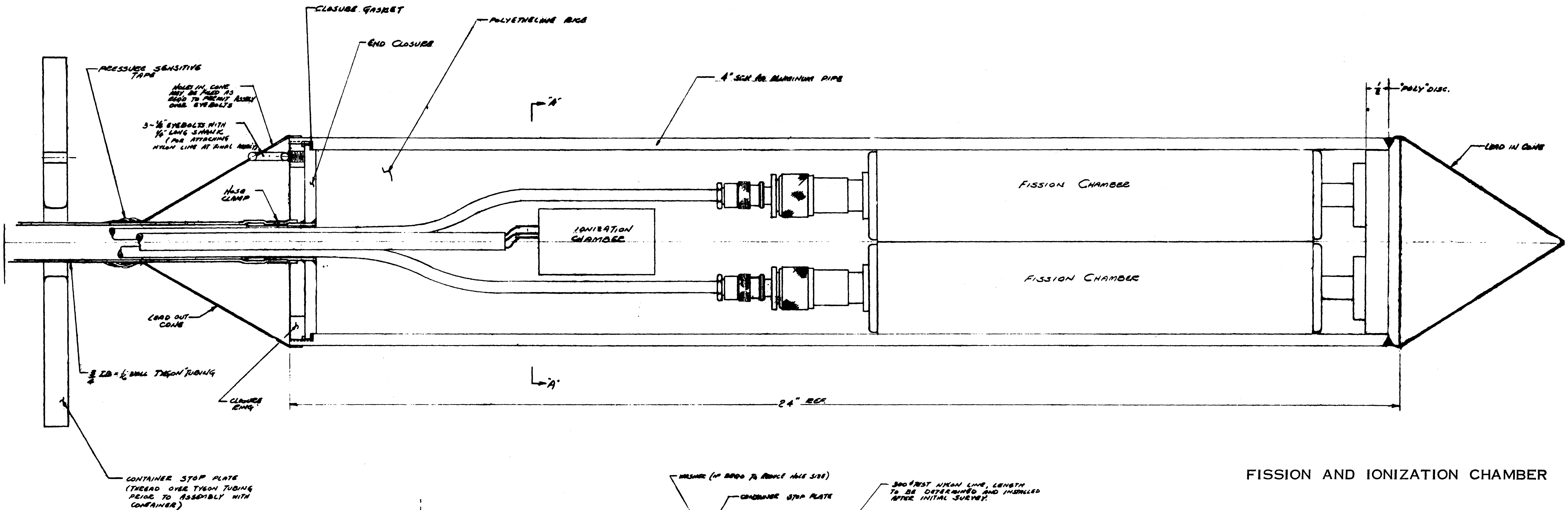

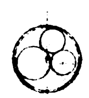

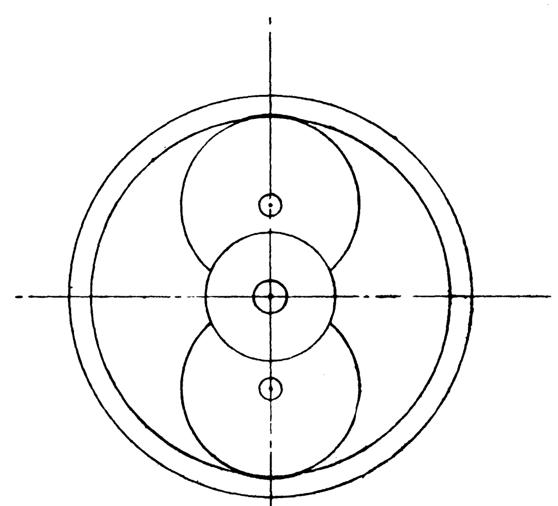

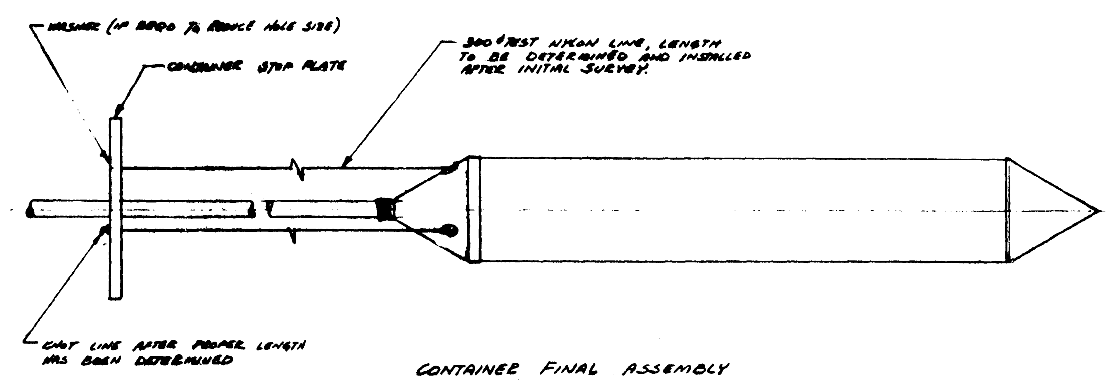

FISSION AND IONIZATION CHAMBER

CONTROL ASSEMBLY

FIGURE III-7

2. COAT 1/32" DIA. SURFACE ON END CLOSURE WITH "PERMATEX" OR OTHER AIR DRYING WATER PROOFING COMPOUND PRIOR TO ASSEMBLY.
1. COAT THREADS WITH "PERMATEX" OR OTHER AIR DRYING WATER PROOFING COMPOUND PRIOR TO ASSEMBLY

NOTES.

PREPARED UNDER AEC CONTRACT AT(10-1) 967

CEND CONTRACT 15458-3

UNLESS OTHERWISE SPECIFIED
DECIMAL TOL.: FRACTIONAL TOL.: ± 1/64
ANGLES: ± 0°-30' FINISH: FILLETS:
BREAK ALL SHARP EDGES 1/64 MAX.

DO NOT SCALE DWG. CALC. WT.:
SCALE: FULL & AS NOTED ACT. WT.:

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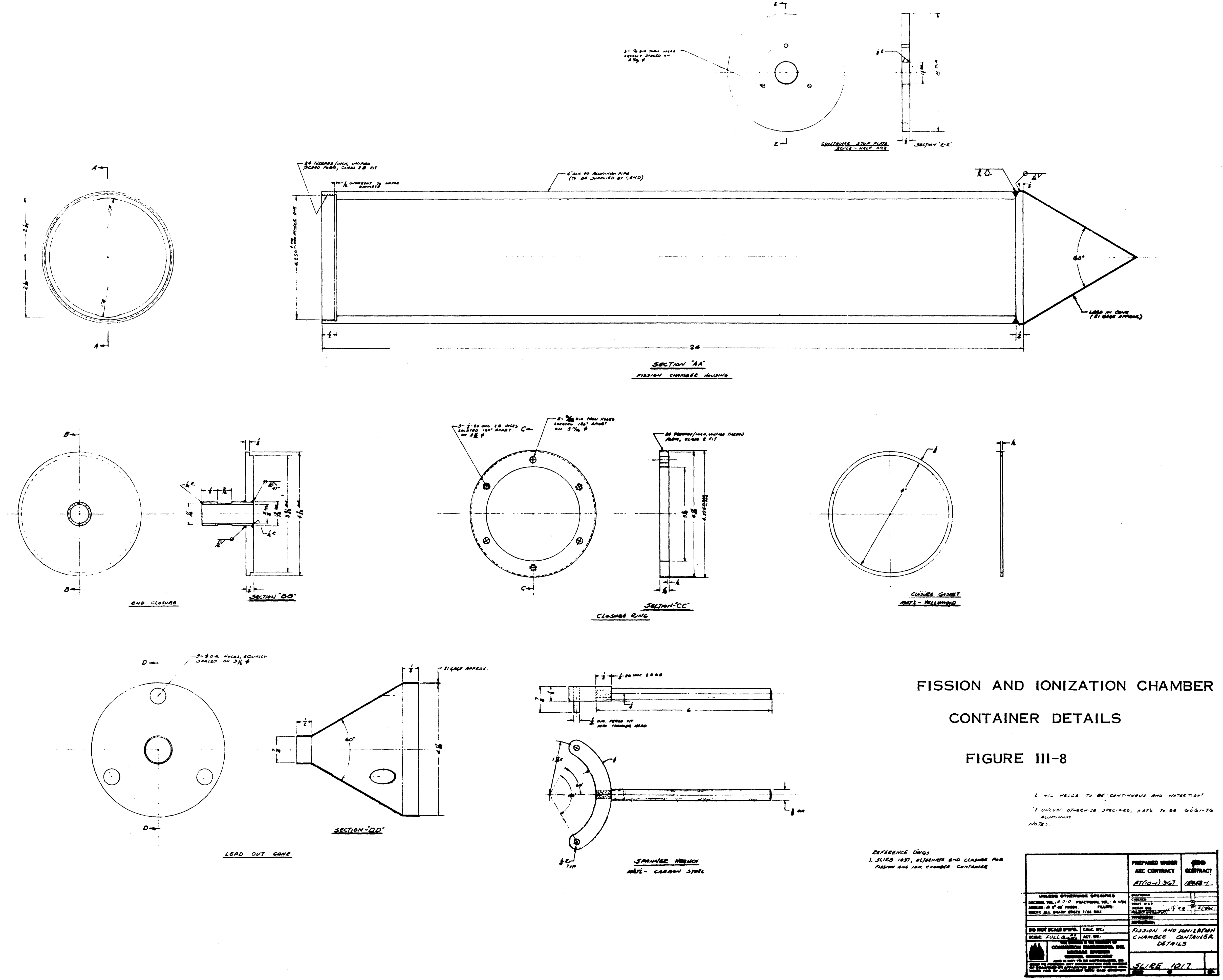
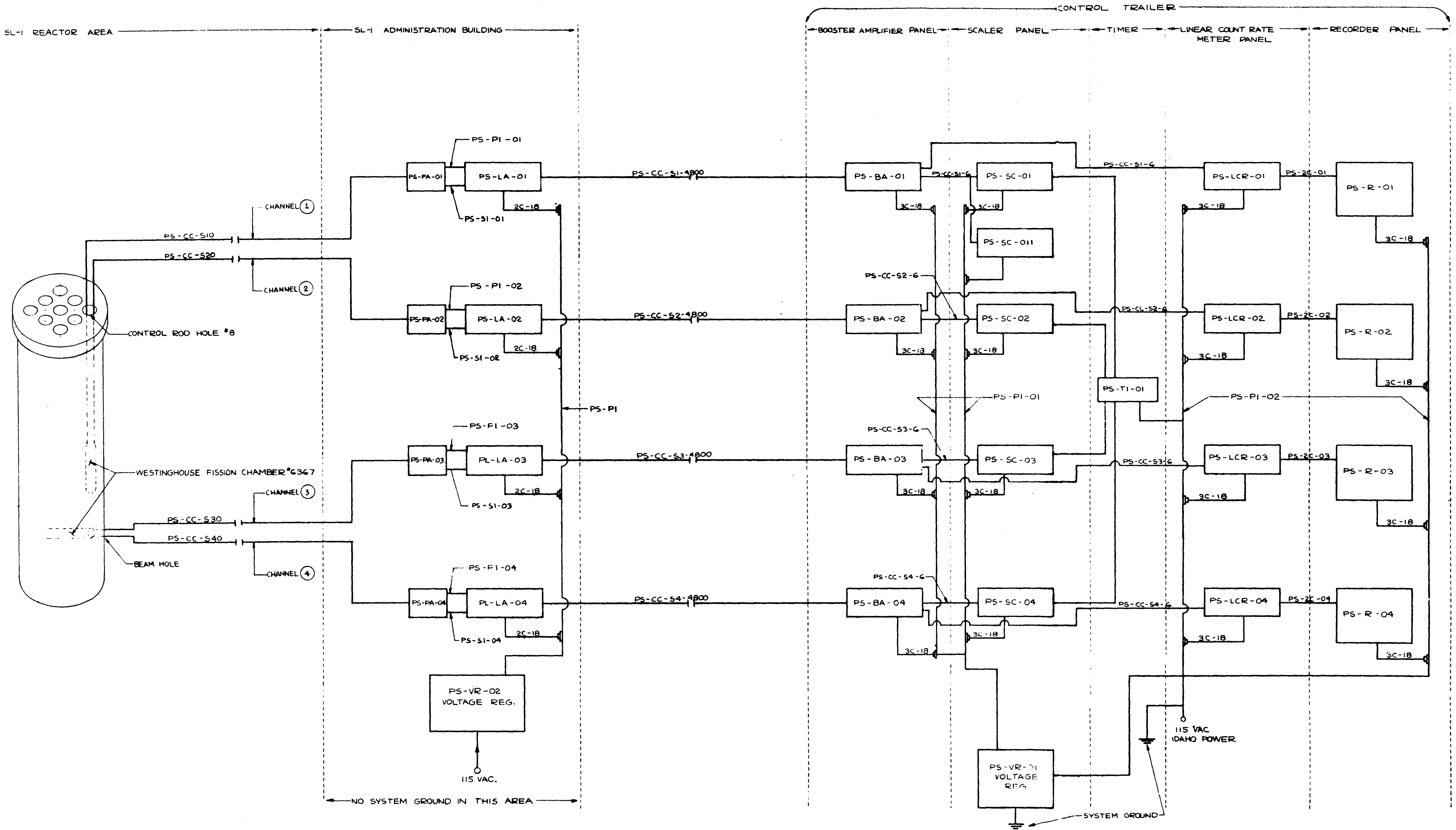
FISSION & IONIZATION CHAMBER CONTAINER ASSEMBLY

SCIRD 1016



FISSION AND IONIZATION CHAMBER CONTAINER DETAILS

FIGURE III-8



COMPONENTS LIST - CHANNEL (1)					
INST. NO	DESCRIPTION	RATING	MFG	NO REQ	REMARKS
PS-PA-01	PULSE TRANSFORMER PRE AMP		SITE ASSY	1	
PS-LA-01	AID LINEAR AMP		VICTOREEN OR EQUAL	1	
PS-BA-01	LINEAR AMP		ATOMIC MODEL 204 B	1	TO BE USED FOR BOOSTER AMPLIFIER
PS-SC-01	SCALER		BERKLEY	1	
PS-LCR-01	LINEAR COUNT RATE METER		RCL	1	
PS-R-01	RECORDER		MINNEAPOLIS HONEY WELL	1	0-10 MV
PS-SC-011	SCALER WITH SPEAKER		BERKLEY	1	
PS-CC-S10	RG-71A/U COAX			1	350 FT (ON SITE)
PS-CC-S1-4800	RG-71/U COAX			1	4800 FT (ON SITE)
PS-CC-S1-6	RG-59/U COAX			2	6 FT INST. INTERCONNECT (ON SITE)
PS-2C-01	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	3 FT INST. INTERCONNECT (ON SITE)
3C-18	3 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	4	6 FT POWER CORD
2C-18	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	6 FT POWER CORD
PS-PI-01	7 CONDUCTOR #20 AWG SHIELDED	300 V	BELDEN	2	3 FT POWER INST. INTERCONNECT ON SITE
PS-SI-01	RG-71A/U COAX			1	3 FT SIGNAL LEAD

COMPONENTS LIST - CHANNEL (2)					
INST NO	DESCRIPTION	RATING	MFG	NO REQ	REMARKS
PS-PA-02	PULSE TRANSFORMER PRE AMP		SITE ASSY	1	
PS-LA-02	A.I.D. LINEAR AMP		VICTOREEN	1	
PS-BA-02	LINEAR AMP		ATOMIC MODEL 204 B	1	TO BE USED FOR BOOSTER AMPLIFIER
PS-SC-02	SCALER		BERKLEY	1	OR EQUAL
PS-LCR-02	LINEAR COUNT RATE METER		RCL	1	
PS-R-02	RECORDER		MINNEAPOLIS HONEY WELL	1	0-10 MV
PS-CC-S20	RG-71A/U COAX			1	350 FT (ON SITE)
PS-PI-02	7 CONDUCTOR #20 AWG SHIELDED	300 V	BELDEN	2	3 FT POWER INST INTERCONNECT (ON SITE)
PS-CC-S2-4800	RG-71/U COAX			1	4800 FT (ON SITE)
PS-CC-S2-6	RG-59/U COAX			2	6 FT INST. INTERCONNECTOR (ON SITE)
PS-2C-02	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	3 FT INST INTERCONNECT (ON SITE)
3C-18	3 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	4	6 FT POWER CORD
2C-18	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	6 FT POWER CORD
PS-SI-02	RG-71A/U COAX			1	3 FT SIGNAL LEAD

COMPONENTS LIST - CHANNEL (3)					
INST NO	DESCRIPTION	RATING	MFG	NO REQ	REMARKS
PS-PA-03	PULSE TRANSFORMER PRE AMP		SITE ASSY	1	
PS-LA-03	A.I.D. LINEAR AMP		VICTOREEN	1	
PS-BA-03	LINEAR AMP		ATOMIC MODEL 204 B	1	TO BE USED FOR BOOSTER AMPLIFIER
PS-SC-03	SCALER		BERKLEY	1	OR EQUAL
PS-LCR-03	LINEAR COUNT RATE METER		RCL	1	
PS-R-03	RECORDER		MINNEAPOLIS HONEY WELL	1	0-10 MV
PS-CC-S30	RG-71A/U COAX			1	350 FT ON SITE
PS-PI-03	7 CONDUCTOR #20 AWG SHIELDED	300 V	BELDEN	2	3 FT POWER INST INTERCONNECT (ON SITE)
PS-CC-S3-4800	RG-71/U COAX			1	4800 FT (ON SITE)
PS-CC-S3-6	RG-59/U COAX			2	6 FT INST. INTERCONNECTOR (ON SITE)
PS-2C-03	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	3 FT INST. INTERCONNECTOR (ON SITE)
3C-18	3 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	4	6 FT POWER CORD
2C-18	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	6 FT POWER CORD
PS-SI-03	RG-71A/U COAX			1	3 FT SIGNAL LEAD

COMPONENTS LIST - CHANNEL (4)					
INST NO	DESCRIPTION	RATING	MFG	NO REQ	REMARKS
PS-PA-04	PULSE TRANSFORMER PRE AMP		SITE ASSY	1	
PS-LA-04	A.I.D. LINEAR AMP		VICTOREEN	1	
PS-BA-04	LINEAR AMP		ATOMIC MODEL 204 B	1	TO BE USED FOR BOOSTER AMPLIFIER
PS-SC-04	SCALER		BERKLEY	1	
PS-LCR-04	LINEAR COUNT RATE METER		RCL	1	
PS-R-04	RECORDER		MINNEAPOLIS HONEY WELL	1	0-10 MV
PS-CC-S40	RG-71A/U COAX			1	350 FT (ON SITE)
PS-PI-04	7 CONDUCTOR #20 AWG SHIELDED	300 V	BELDEN	2	3 FT POWER INST INTERCONNECT (ON SITE)
PS-CC-S4-4800	RG-71/U COAX			1	4800 FT (ON SITE)
PS-CC-S4-6	RG-59/U COAX			2	6 FT INST. INTERCONNECTOR (ON SITE)
PS-2C-04	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	3 FT INST. INTERCONNECTOR (ON SITE)
3C-18	3 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	4	6 FT POWER CORD
2C-18	2 CONDUCTOR 18 AWG STRANDED (RUBBER COVERED)	300 V	BELDEN	1	6 FT POWER CORD
PS-SI-04	RG-71A/U COAX			1	3 FT SIGNAL LEAD

COMPONENTS LIST - CHANNEL (1)(2)(3)(4)					
INST NO	DESCRIPTION	RATING	MFG	NO REQ	REMARKS
PS-TI-01	TIMER	0-60 SEC. 0-60 MIN		1	PRECISION TIMER, WITH PRE-SET & ELAPSED TIME INDICATOR
~~PS-VR-02~~	~~VOLTAGE REG~~	~~2.5 KV~~	SUPERIOR ELECTRIC		LOCATED IN SL-1 CONTROL RM.
PS-VR-01	VOLTAGE REG	5 KVA	SORENSEN	1	OR EQUAL
PS-P1-02	PLUG-IN STRIP	15A, 125V	NATIONAL	1	#CF2G-606-6 69" LONG WITH 11 OUTLETS
PS-P1-01	PLUG-IN STRIP	15A, 125V	NATIONAL	1	#CF2G-606-6 60" LONG WITH 11 OUTLETS
PS-P1	4" SQ BOX, DUPLEX OUTLETS	125V			
CHANNELS 1, 2, 3, 4.	FISSION CHAMBERS			4	WESTINGHOUSE # 6367 OR EQUAL

CONTROL TRAILER,

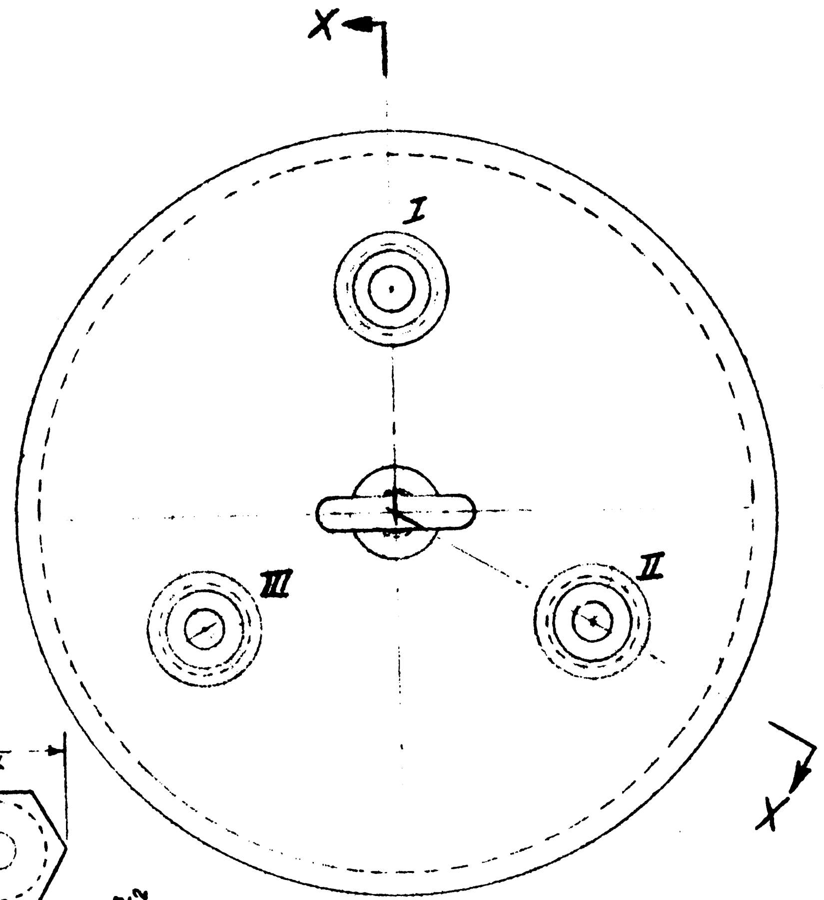
NUCLEAR INSTRUMENTATION DRAWING

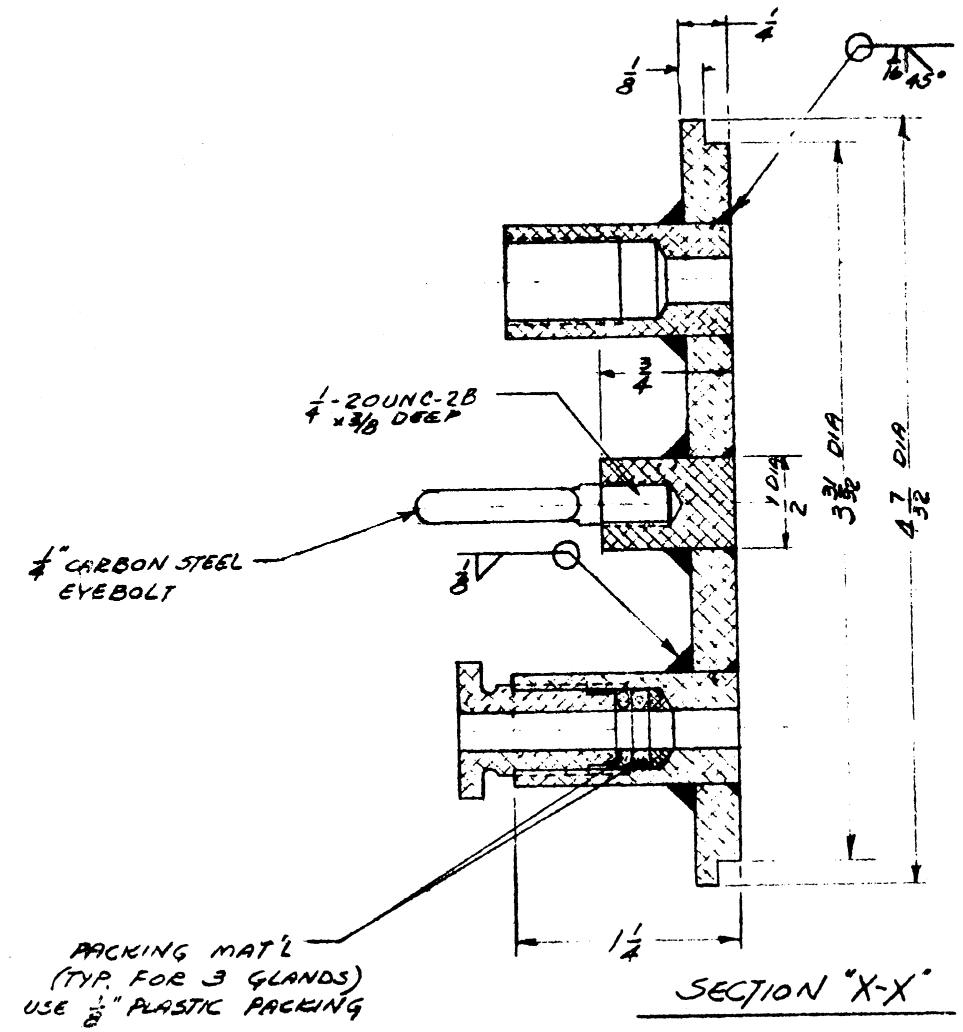
FIGURE III-9

PREPARED UNDER AEC CONTRACT

CONTROL TRAILER NUCLEAR INSTRUMENTATION DRAWING

SL1RJ1031



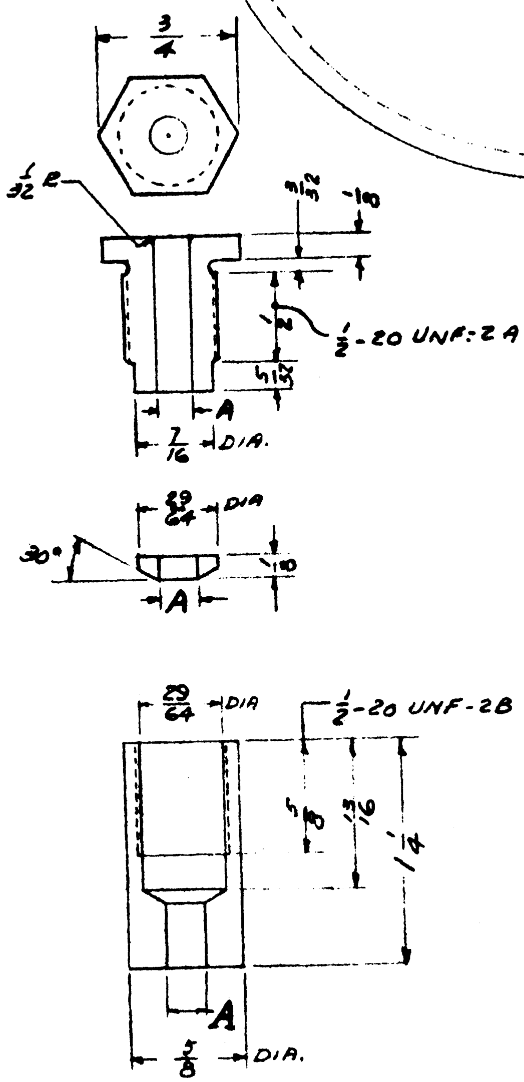


ALTERNATE END CLOSURE FOR

FISSION AND ION CHAMBER

FIGURE III-10

REF. DWGS.
1- SL1RE 1017.- FISSION AND IONIZATION - CHAMBER CONTAINER DETAILS



GLAND DETAILS
(3 REQ'D)

GLAND No.	I	II	III
"A" DIM.(DIA)	1/4	7/32	7/32

NOTES.

1. WELD SYMBOLS APPLY TO ALL SIMILAR JOINTS
2. ALL MAT'L TO BE 6061-T6 ALUMINUM, UNLESS OTHERWISE SPECIFIED
3. ALL WELDS TO BE CONTINUOUS AND WATERTIGHT.

	PREPARED UNDER AEC CONTRACT AT(10-1) 967	CEND CONTRACT 1545B-3

UNLESS OTHERWISE SPECIFIED
DECIMAL TOL.: FRACTIONAL TOL.: ± 1/64
ANGLES: ± 0°-30' FINISH: FILLETS:
BREAK ALL SHARP EDGES 1/64 MAX.

DRAFTSMAN: EG — DATE 5/2/61
CHECKER:
DRAFT. M'G'R.
DESIGN ENG. WK / EG — 5/2/61
PROJECT M'G'R.
SUPERSEDES:
SUPERSEDED:

DO NOT SCALE D'W'G. — CALC. WT.:
SCALE: FULL SIZE — ACT. WT.:

ALTERNATE END CLOSURE FOR FISSION AND IONIZATION CHAMBER CONTAINER

SL1RB 1037

SHEET OF — REV.

The flexible hose positioned on the operating floor was rigidly held by a support structure. The sonic probes would be lowered by the same type of pulley arrangement used in previously successful entries.

The nuclear instrumentation consisted of four Westinghouse fission chambers. Two chambers would be installed in the SL-1 beam hole. Two remaining chambers would be housed in a container capable of penetrating SL-1 No. 8 nozzle and lowered into the reactor vessel using a pulley arrangement.

(6) Poison Solution Makeup

Two thousand gallons of boric acid solution of the required concentrations would be made up in the four storage tanks mounted on the rig. Chemical analysis of the concentration in each tank was to be performed following the mixing operation and after eight hours of circulation.

(7) Installation of Equipment in Reactor

The Austin-Western crane would position the spray nozzle and level detector systems in the reactor tank. All connections would be made up; instruments, electrical, and nuclear instrumentation activated and checked.

IV SL-1 DECONTAMINATION AND CORE REMOVAL PLAN

A. OBJECTIVES

The proposed plan (reference 10) covers the decontamination of the SL-1 reactor building; the removal of the reactor core; and the decontamination of the support buildings, grounds and roadways to the facility. The method of approach to decontamination and disassembly of the reactor plant contemplates minimum radiation exposure to personnel. A concurrent effort to accumulate evidence needed to determine the cause and extent of the nuclear excursion would be conducted.

The plan is separated into two tasks: (1) High level decontamination by remote techniques; and (2) Low level decontamination by direct personnel effort.

B. HIGH LEVEL DECONTAMINATION PLAN

The plan for high level decontamination includes performance of radiation surveys to locate radiation sources and removal of these sources by use of remote handling equipment. The decontamination effort will start after shielding of the core by filling the reactor vessel with a solution of boric acid.

1. Phase I - Reconnaissance and Preparation for Decontamination

a. Photographic and radiation mapping of the operating room floor would be conducted by traversing with shielded movie cameras. It was proposed to mount two motor driven 16 mm movie cameras, in a lead shielded box with one camera pointed upward and the other pointed downward. The box would be supported from the motor driven traveling boom on the Austin Western crane. Floodlights would be mounted on the box as necessary to obtain proper exposure of the photographic film. Two collimated ionization chambers would be mounted in the camera box adjacent to each camera lens opening. They would be collimated with lead shielding so that their scanning field coincided with the field of vision of each movie camera. The meters which indicate the radiation level detected by each ion chamber would be located on the Austin-Western crane. An additional motor driven movie camera would be mounted such that it would photograph both meters. The three cameras would be set to take 16 frames per second and would be connected to a common power supply, to ensure synchronous operation. The cameras would be started simultaneously upon entry and would provide a record of the radiation levels for every frame of movie film of the operating room. The radiation levels and photographs could then be compared and evaluated to locate high radiation areas and objects.

The vertical position of the camera box would be set to ensure missing any obstructions and to optimize the field of vision of the two cameras.

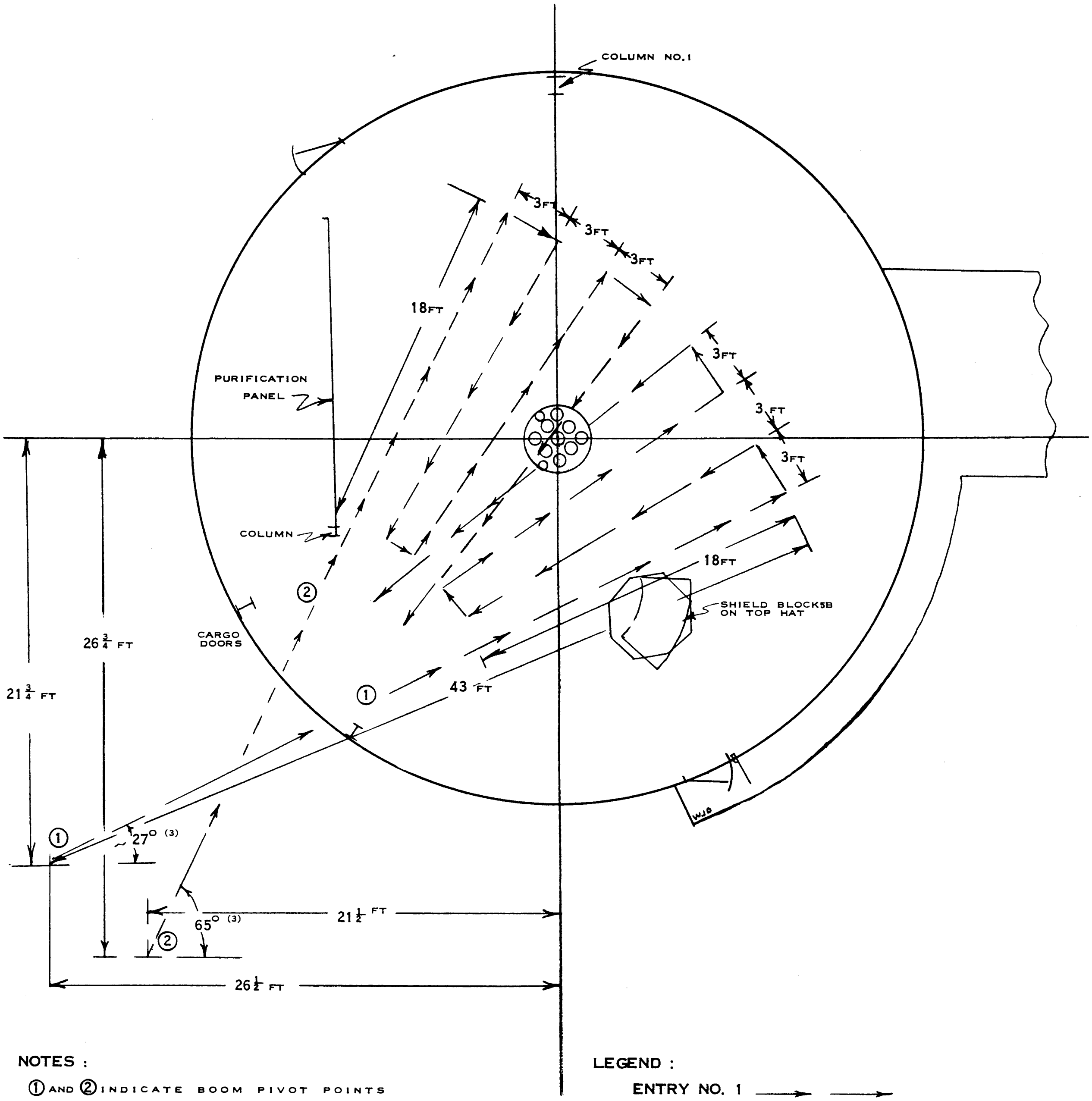
To photograph the area involved, it would be necessary to perform two entries. Each would involve four 18 foot traverses. The position of the crane for each entry and the plot of the proposed traverses are shown in Figure VI-1. The camera would be operated during the boom entry, exit, and each traverse but would not be operated when panning the boom from one position to the next, ensuring that the 100 feet of film was not exposed before the entry was completed. The motor driven boom to which the cameras would be mounted, moves at a constant speed of approximately 30 feet per minute.

b. Access for photographic and radiation mapping of the fan room would be accomplished by cutting an entry hole through the reactor building wall above the fan floor. The hole location would be based on the evaluation of the photographs obtained in entries described above. The entry hole would be cut by a man located in a lead coffin suspended from the 60 ton crane. The equipment is described in a later section. The photographic entry would be made through the hole using the same techniques as above, but with a change in camera and radiation survey instrument orientation and with the addition of a television camera to guide the entry.

c. A positive filter system would be installed in the operating room to prevent dust and other particles from migrating to the atmosphere during decontamination operations. A hole would be cut in the reactor building wall by a man suspended in the shielded coffin. The ventilating system which would have a capacity of 20,000 CFM and the necessary duct work would be mounted outside the reactor building. The unit would be equipped with positive filters to reduce the radiation level of the exhaust air to tolerable levels. This system would provide an inlet air velocity of three feet per second through the freight door. It would be provided with an alarm and shutdown system in the event of excessive radiation in the exhaust.

d. A fixed television camera system would be installed in the reactor operating room to provide viewing for some of the remote operations in the reactor building. For entries requiring close viewing, an additional television camera would be mounted on the crane boom. The two television cameras would be used to obtain necessary depth perception.

e. A vehicle decontamination pan would be installed on the ground under the freight door. This decontamination pan was designed for the collection of particles that could fall from the reactor tank while removing pieces or parts of equipment. It could also be used for the collection of decontaminants and particles while cleaning vehicles before leaving the SL-1 facility.



NOTES :

① AND ② INDICATE BOOM PIVOT POINTS FOR ENTRY 1 AND 2.

(3) EXACT PATH OF FIRST TRAVERSE WILL DEPEND ON LIMITING OBJECTS (COLUMNS, SHIELD BLOCKS 5B, ETC.)

LEGEND :

ENTRY NO. 1 ——→ ——→

ENTRY NO. 2 — — → — — →

PHOTOGRAPHIC TRAVERSE PLAN IN REACTOR OPERATING ROOM

FIGURE IV-1

2. Phase II - Removal of Highest Radiation Sources

a. The four shield plugs would be removed from the reactor building with the crane and motor driven boom.

The method and sequence of grasping each shield plug would depend on its location. The fôllowing is a tentative plan pending further information from the radiation surveys.

(1) Using a double hook device suspended from pulleys on the crane boom, the plug which is located across the top of the reactor would be engaged and lifted out. A closed circuit television system with the camera fixed to the boom and pre-focused would provide the eyes for this operation.

(2) With a single hook suspended from pulleys on the crane boom, plugs would be installed in each of the six open control rod nozzles. A closed circuit television system with the camera mounted to the boom would provide the viewing for this operation.

The installation of the plugs at this time would prevent material from falling into the reactor during subsequent operations.

(3) The shield plug which is lodged in the ceiling over the reactor would be removed by use of a remote controlled mechanical arm to engage a hook or shackle to this plug. The mechanical arm with a closed circuit television viewing system would be mounted on the end of the boom. Once the hook or shackles was engaged, it would be pulled up snug to the boom and the crane backed out.

(4) To remove the remaining two shield plugs would require determining their location and removal as discussed above.

b. The remaining hot spots would have been located by the photographic and radiation mapping operation of Phase I. The technique for their removal will depend on the source and location of the radiation. In general, the following operations would be required:

(1) An electromagnet suspended from the crane boom would be used for removal of magnetic objects on the floor (steel punchings, tools, etc.). A five gallon container would be placed on the operating floor with the boom and loaded using the magnet which would pick up objects by traversing across the floor. When the bucket was filled it would be removed and inserted into a shielded container on the ground, and the operation continued with another container.

The material recovered would either be shipped to the temporary burial ground or held for further inspection.

(2) Tongs operated from a lead coffin or manipulator hands would be used for removal of other moderately sized objects. This coffin, which will hold one man in the kneeling position, was successfully used in previous operations.

(3) A vacuum system operated by the manipulator would be used for removal of small objects on the operating floor or material splattered against the ceiling or vertical surfaces.

(4) If high level contamination can not be removed from surfaces by vacuuming alone, then the surfaces would be remotely sandblasted and vacuum cleaned.

(5) If none of the above techniques are successful, the contaminated surface could be removed by using a cutting torch, which is handled with the manipulator.

3. Phase III - Operating Floor Clean-Up

a. A general clean-up of the floor between the freight door and the reactor would be performed, first by using an electro-magnet suspended from the crane boom, and then by using a vacuum cleaner mounted on the boom.

b. All accessible surfaces of shield blocks No. 1 and No. 2 would be vacuum cleaned.

c. Shield blocks No. 1 and No. 2 would be skidded to the freight door, then lifted out by the second hydraulic crane. The limited overhead clearance and light steel floor adjacent to the freight door would require the use of special skids for supporting the blocks during removal through the freight door.

d. Remaining debris would be removed from the ceiling and structural members with the vacuum cleaner operated from the manipulator.

e. Remaining debris would be removed from the operating floor, top of the reactor, instrument well trench around the reactor, and the top of the shield blocks by using the electromagnet, vacuum cleaners, and rigging as dictated by the type and size of the debris.

f. The top of the reactor would be covered with lead plates or steel shot if radiation from the reactor makes it necessary.

g. The removal of the remaining debris from the fan room would be accomplished by using the vacuum cleaner and electromagnet.

h. The reactor monitoring system would be reactivated and an audible alarm would be installed.

i. The overhead crane would be repaired.

j. Using the overhead crane, the remaining shield blocks would be moved to the freight door and then lifted out with the second hydraulic crane.

k. The final clean-up of the operating floor would then be accomplished.

C. PLAN FOR LOW LEVEL DECONTAMINATION

The general plan for the task of low level decontamination is to continuously perform radiation surveys and to remove detectable contamination from the SL-1 facility. To accomplish the plan, special equipment and facilities for the decontamination of SL-1 equipment, buildings, and grounds were designed and procurement initiated.

Following SL-1 deactivation, low level decontamination would be initiated and performed in the following steps:

1. The facility road would be decontaminated by using several methods:

a. Vacuum cleaning utilizing the special shielded vacuum system

b. The contaminated areas would be scrubbed using detergents and/or various decontamination solutions, followed by mopping and/or vacuum cleaning.

c. Contaminated road areas resisting the above efforts would be removed using a chipping tool (jackhammer) or blade on a vehicle.

2. A portable vehicle decontamination station would be set up at the edge of the contaminated area. Its purpose would be to decontaminate all vehicles before they leave the SL-1 facility. The station would be picked up and moved closer to the reactor building as the contaminated zone was reduced.

3. Access to the waste disposal area from the SL-1 Site would be provided by a road from the SL-1 Site. This would be surfaced to allow heavy vehicle access.

4. Contaminated materials and equipment removed from the SL-1 Site would be held in a temporary disposal area until final disposition.

5. Upon completion of SL-1 core deactivation or shielding, a survey of direct radiation, contamination, and air activity would be made in and around the AREA Support Facility (Hot Lab). Health Physics would determine if the area could be occupied. If the survey indicated direct radiation to be a problem, the use of a dirt mound for shielding between

the SL-1 and Hot Lab would be considered. Any low level contamination in the Hot Lab area would be handled by the same methods to be used in decontamination of the SL-1 facility. Assuming a clean area, the Control Point would be moved to the Hot Lab. Health Physics would provide personnel protection. An alarm system for direct and airborne activity in this area would also be supplied.

6. Decontamination of Equipment

a. A low level decontamination building would provide a facility to process and decontaminate, where determined feasible, reusable equipment such as desks, chairs, typewriters, calculating machines, tools, machines, etc.

b. The low level decontamination process is generally as follows:

(1) All contaminated materials would enter the building through the entrance antichamber where it would be sorted and monitored.

(2) The equipment would then be brought into the building proper where it would be vacuum cleaned and wiped with clean, dry rags.

(3) Monitoring would again be conducted and decontamination feasibility would be determined at this point. The material would then be either rejected or would continue through the decontamination process.

c. Material determined feasible for decontamination would be categorized into one of three possible channels of decontamination, these would be as follows:

(1) Lightly contaminated articles would be channeled through the process along one side of the building where tables or benches would be set up for hand washing and wiping with damp rags. These items would then be air dried.

(2) Larger articles (chairs, desks, etc.) and the more heavily contaminated objects would be channeled through the center of the building where a polyethylene tent would be erected. The contaminated items would be steam cleaned and water rinsed. These services would be available within the tent. The items would be allowed to drain and air dry.

(3) Smaller, more heavily contaminated articles would be channeled along the other wall where dipping tanks would be installed. The articles would be sorted and loaded into wire baskets and dipped into a hot detergent solution tank. This tank would be equipped with a steam nozzle if agitation is required. The detergent solution dip would be followed by two clean water dips, after which the articles would be allowed to air dry.

(4) All decontaminated articles would then be brought into the exit chamber where final monitoring would be conducted under minimum background conditions.

Disposition of decontaminated articles would be made by Health Physics, the articles may be released for reuse, or may require reprocessing if any contamination persists.

During low level decontamination operations, a filtered ventilation system would be required to keep airborne radiation levels down to acceptable levels. A small portable ventilation system would be available for such use.

7. Area Decontamination

a. Contamination would be removed from the SL-1 grounds by digging and/or scraping, placing it in containers, and burying it in the temporary burial ground.

b. The exteriors of the buildings will be decontaminated by vacuuming, detergent washing, and sandblasting teachniques.

c. Decontamination of the SL-1 Administration and Support Facility Building interiors would require removal of all furniture and equipment from these buildings through the decontamination building.

After the removal of equipment, decontamination teams would proceed to decontaminate the building interiors, section by section, maintaining a clean area behind them. Sealing off the high level work from low level operations may be necessary because of airborne activity from the high level decontamination operations.

Completion of the high level decontamination work would reduce the radiation levels to a point where personnel would be permitted to spend appreciable periods of time in the operating areas. At this stage in the operations, decontamination teams could proceed in a similar manner to that outlined above for the decontaminating of the support areas.

d. As a result of photo entries and preliminary inspection of components and debris removed from the reactor building, the disposition of each item will be determined.

Items which have no future use and cannot contribute to the knowledge of the cause or effect of the incident would be buried. They would be sealed in suitable containers or sprayed with a fix coat and removed to the temporary disposal area.

Items that would be worth decontaminating for their future use or for incident information would be decontaminated. If their level of contamination is above the limits of the low level decontamination building they would be placed in suitably shielded containers and be removed to the NRTS Chemical Processing Plant for decontamination.

The quantity and composition of radioactivity on each highly contaminated component would be determined.

D. PLAN FOR CORE REMOVAL

Following the decontamination of the operating room and fan room to an extent that limited access would be permitted the core inspection and removal would be conducted. A plan is presented below:

1. The building would be cut away and equipment removed from the fan floor as necessary to permit core removal equipment to be positioned over the reactor vessel.

2. Temporary roofing would be installed as necessary to provide weather protection.

3. Complete photographic surveying of the top of the core and the vessel walls through the ports in the head would be performed.

4. Equipment on the reactor vessel head would be disassembled and then the vessel head removed. The bridge crane would be used. An inspection of the head and the head bolts would be made to determine if there were any yielding or structural failure.

5. Piece by piece removal of loose components with the reactor vessel would be performed. Photographing the core whenever a new area is exposed would be done on a continuing basis. Shielded containers would be provided on the operating room floor for these components.

6. Solid poison strips would be inserted where possible into the core area.

7. Fuel elements would be removed intact and solid poison strips inserted in place of each element after it is removed where possible. Elements should be placed in individual casks and removed for further inspection in appropriate facilities.

8. The core structure would be cut away and pried as necessary, using shears, tongs and levers to permit removal of remaining fuel elements.

9. When all fuel elements have been unloaded the temporary poison strips would be removed.

10. The remaining debris resting on the bottom of the vessel would then be removed.

11. Following removal of all material from the vessel it would be inspected for structural yielding.

E. RAZING OF REACTOR BUILDING

Upon completion of core removal the balance of the reactor building would be torn down. This task would be accomplished by first removing all remaining machinery from above the operating floor level in the reactor building, lifting of the deck plate and removal of all piping attached to the reactor vessel, and removal of all gravel shielding. The reactor vessel then would be removed and skidded to the burial grounds. The balance of the reactor building would then be stripped to ground level and the area under the building checked for contamination.

F. PLAN FOR SL-1 FACILITY INSPECTION

During clean-up of the reactor and reactor building, a complete description would be compiled of the state of the reactor, the reactor building, the location of equipment and tools, the location of debris, etc. Whenever possible, this description would be illustrated by photographs which show the spatial disposition of all the objects found in and around the reactor building subsequent to the accident. As complete a record as possible would be assembled to avoid losing information which may not seem significant at the time, but may be of value. Care would be taken to record any rearrangements of the contents of the reactor building which result from penetrations made since the incident. The location and condition of any tools or equipment left in or about the reactor building during operations subsequent to the accident would be recorded.

1. Information Obtained Outside the Reactor Vessel

a. Physical Arrangements

After the deactivation of the reactor, a complete photographic survey of the interior of the reactor building, including both the operating floor and the fan floor, would be performed. From these photographs, it should be possible to identify the tools and equipment which were available or in use at the time of the accident. A continuing search would be maintained for mechanical evidence of the force of the explosion. The trajectories and effects of missiles would be recorded in as much detail as access permits. Any broken or overstressed parts would be examined as carefully as the radiation level permits; photographed completely, and preserved for future examination. When work is performed on the head, its mechanical condition would be examined in detail, and any possible observations relative to the overstressing of the head, the bolts and all other parts would be made before the head or the bolts are otherwise disturbed. All parts of the control rod mechanisms would be located and evidence obtained to determined whether they had been on the reactor and ejected (along with evidence of trajectory), or whether they were lying in readiness for re-assembly.

b. Radiation Survey

A complete map of the radiation intensity within the SL-1 reactor building would be made. The pin-hole camera or other techniques would be employed to locate and measure the main sources of radioactivity. The amount and extent of fuel expelled from the reactor core would be estimated from this map. Exact locations and conditions of each piece of fuel or other "hot" material would be logged and a permanent record kept of each item.

Any entrance into the fan room would be made with great care in order not to disturb material that may be present in this area before photographs and radiation measurements are obtained.

c. Evidence of Neutrons and Material Ejected from the Reactor

Of primary importance in connection with the collection of evidence in the reactor operating room is a careful inventory of all items, their location, physical appearance and disposition. The following items may furnish evidence as to the nature and extent of the incident.

(1) An inventory of fuel and fuel elements found outside the vessel would be made. The fuel would subsequently be analyzed for extent and location of melting; evidence of multiple melting and resolidification; evidence of aluminum-water reaction; amount of U^{235} burnup. This last item would be helpful in correlating the final position of a given fuel sample with its position before the incident.

(2) Flexitallic gaskets, which were newly installed would be analyzed for chromium-51 (27 day half-life) and cobalt-58 (71 day half-life). Other new stainless steel items would yield the same information. It should be pointed out that these activities will be very low and it may be too late to obtain useful information from these items.

(3) Number 4 control rod had a "stellite" bushing installed during shutdown. "Stellite" has a high cobalt content which would provide accurate information for flux calculations. Subsequent records may verify that this bushing was used once before about two years ago. If so, the residual cobalt-60 activity would render any analysis useless.

(4) Several light bulbs with Tungsten filaments are readily available. The Tungsten activity (W-185 half-life = 74 days) will be very low and it may be too late to measure this activity.

(5) Samples of the material shown in the movie on the floor adjacent to the reactor are of interest. This may be blotting paper, or perhaps, pieces of aluminum which were ejected from the core in molten form and solidified on the floor. In addition, the nature of the white matter on the ceiling above the reactor would be determined.

(6) Evidence of lifting the pressure relief valves would be collected either by examination of the valve or radioactive contamination on the downstream side of the valve. This may furnish an indication of the pressure buildup during the incident.

(7) Smears would be taken on the shield plug removed with the third body and checked for aluminum oxide, nickel, and enriched uranium. This information would give additional evidence as to aluminum-water reaction and the extent of core meltdown.

(8) The filter inserts and ion-exchange resins in the coolant system and by-pass purification system would be retained for analysis of total and dissolved solids (especially boron), and fission products.

If the coolant system was in operation during the incident, products of any chemical reaction in the core would be present. All water in the system between the reactor and the ion-exchange columns would be collected, if possible, to provide a sample of water from the reactor following the incident.

(9) The volume of water in the contaminated water tank would be measured. This should indicate the volume of water in the vessel at the time of the excursion. A sample of this water would be analyzed for total and dissolved solids, pH, conductivity, and fission products.

(10) Water samples would be obtained at as many points in the plant as possible; e.g., filters, ion-exchange columns, contaminated water tank and steam line. These samples would be analyzed for total and dissolved solids (especially boron and aluminum oxide), pH, conductivity and fission products. If the water circulation system was in operation, it may be possible to characterize any chemical reactions that may have initiated the nuclear excursion.

2. Physical Observation

Visual (photographic) observations of the core would be made to the greatest possible extent. This would be begun before any objects inside the vessel are disturbed and would continue during the core disassembly. In this process the following would be looked for:

a. The position of core components following the incident in an attempt to relate these with positions before the incident.

b. The position and extent of melted fuel.

c. Whether the added cadmium strips are in place in the core, Tee-rod positions 2 and 6.

d. The number of boron strips still in the core.

f. Damage to control rod extension shafts.

During the disassembly of the core, a record of the positions and quantities of fuel, boron strips, cadmium strips, control rods and cobalt flux wires will be compiled. The exact location of each item prior to its removal from the vessel is of utmost importance. It would probably be found, as fuel samples are recovered, that there are several characteristic types of samples such as melted, partially melted, and unmelted. These will be examined for the following:

a. Size distribution of melted or nearly melted fuel particles.

b. Evidence of centerline melting in apparently unmelted plates.

c. Evidence of multiple melting and re-solidification.

d. Evidence of aluminum water reaction.

In addition, the control rods and the core structure would be examined for evidence of melting during the incident.

3. Analysis of Core Components

Once the core is disassembled, the following detailed analyses of the various items are recommended:

a. Metallographic and chemical analysis of the fuel would be carried out to determine the pattern of melting of the plates (multiple melting, melting at the center line, etc.) and to search for oxides of aluminum and uranium. Analysis for the amount of U^{235} burnup will be useful in correlating the position and extent of melting of a sample with its location before the incident (assuming that this is not obvious from the final reactor configuration).

b. Recovery and analysis of some of the cobalt flux wires are of great importance. Identification of the radial and axial location of each wire in the core is of almost equal importance, since there will be an uncertainty of a factor of 4 or 5 in interpreting the wire activation if its location is unknown.

c. A careful search would be made for boron flakes or plates lying at the bottom of the vessel. The boron plates still in the core and any boron collected from the bottom of the vessel will be analyzed for boron burnup. An unirradiated boron aluminum plate will be analyzed for boron content to provide a base point. Metallographic and chemical analysis of the boron strips will be performed.

d. Metallographic and chemical analysis of the control rod blades will be made.

Two AEC laboratories have expressed interest in obtaining fuel samples from the core; ANL for aluminum water reaction analysis and ORNL for fission product distribution analysis. Requests from other sources are anticipated.

G. SPECIAL EQUIPMENT

1. Equipment List

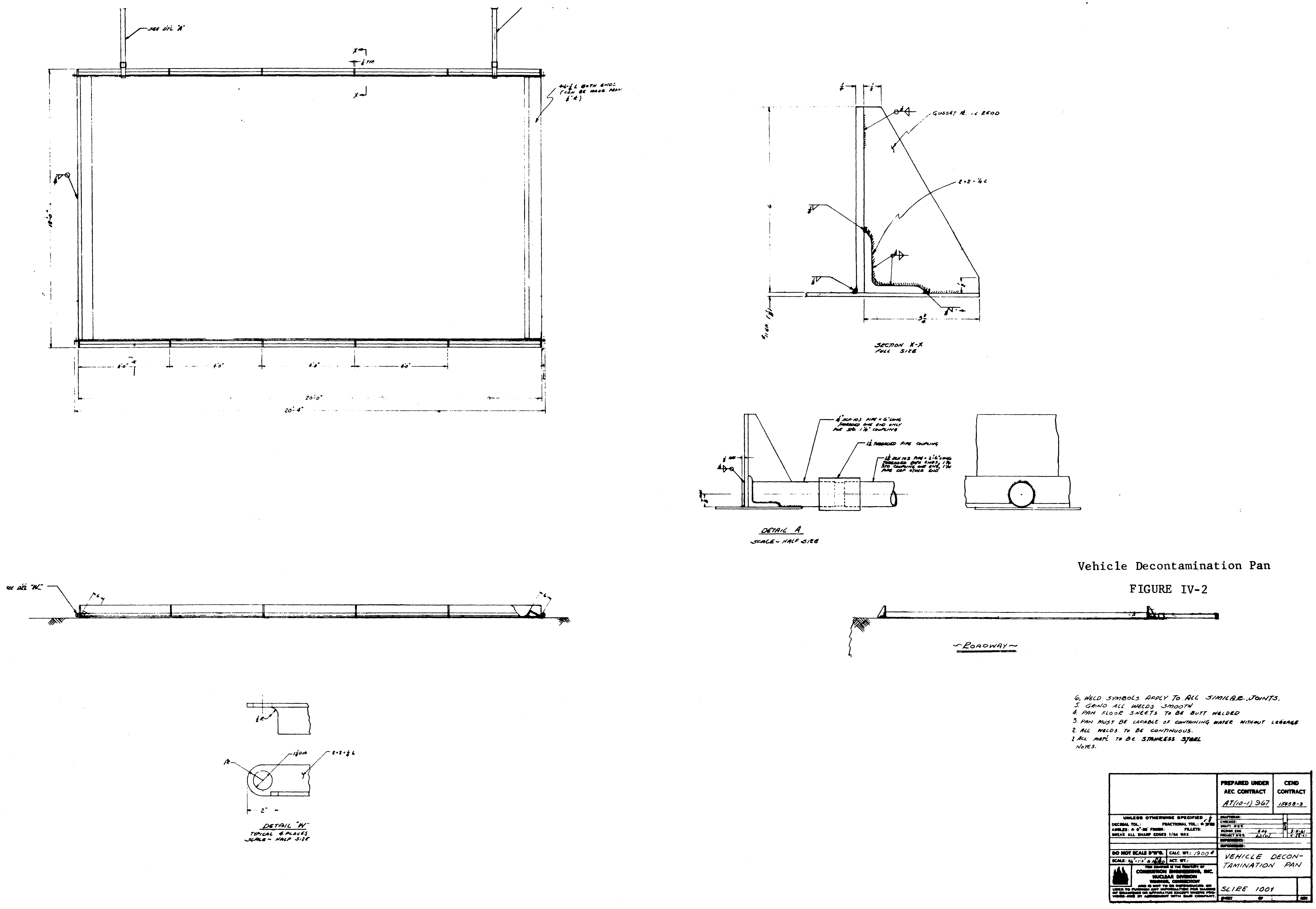
Figure	Drawing	Title
IV-2	SL1RE 1001	Vehicle Decontamination Pan
IV-3	SL1RD 1002	Low Level Decontamination Flow Chart (7 sheets)
IV-4	SL1RJ 1004	Traveling Beam Assembly
IV-5	SL1RE 1005	Traveling Beam Details - Structure
IV-6	SL1RJ 1006	Traveling Beam Details - Machining
IV-7	SL1RD 1007	Vacuum Pick Up In-line Filter Unit
IV-8	SL1RB 1008	Baffle for Vacuum Decontamination System
IV-9	SL1RA 1035	Filtered Vacuum Unit
IV-10	SL1RD 1039	Filter Shielding Box
IV-11	SL1RE 1009	Traveling Beam - Television Camera
IV-12	SL1RE 1011	Vehicle Decontamination Apron
IV-13	SL1RC 1036	Shield Plug Control Rod Nozzle
IV-14	SL1RA 1040	Location of Temporary Waste Disposal Area
IV-15	SL1RA 1041	Waste Disposal Pit
IV-16	SL1RA 1042	Waste Disposal Area
IV-17	SL1RJ 1043	Shielding Box Twin Camera
IV-18	SL1RA 1044	Portable Cleaning System

2. Equipment Description

a. Portable Vehicle Decontamination Pan (Figure IV-2)

The vehicle decontamination pan was designed for the collection of decontaminants and particles while cleaning vehicles and equipment. The pan was to be fabricated from stainless steel, and was of all welded construction. The welds were to be ground smooth to facilitate decontamination of the pan. The pan was to lay directly on the road surface during use. Two lugs on each end were provided for lifting or skidding. Two drain pipes were provided for drainage to suitable containers, such as 55 gallon drums. The drains were equipped with extensions that are removable to provide ease in handling. The pan was designed for use on a solid road surface only. Use on sand or gravel surface would probably result in excessive deformation. The pan should be located on the road surface so as to provide maximum drainage to collection containers located by the roadside.

No provision was incorporated into the design for lack of traction on the pan surface. If difficulty is experienced, a series of weld beads could be laid or strips could be welded to the pan surface to improve vehicle traction. The pan is 12 feet wide by 20 feet long and weighs approximately 1900 pounds. If the pan was required to accommodate a vehicle longer than 20 feet, the vehicle would be decontaminated in sections, as each section is located over the pan. The portable steam cleaning system was designed and fabricated to provide a mobile source of high pressure steam for decontamination operations. These operations include the following:



Vehicle Decontamination Pan

FIGURE IV-2

(1) Vehicle decontamination

(2) Building decontamination

(3) Low level decontamination building steam service

The heart of this system is a low pressure gas fired combination steam cleaning machine. This unit provides the following capacity:

(a) High pressure steam - 240 gph at 200 psi and 325°F

(b) High pressure hot water - 360 gph at 300 psi

(c) High pressure cold water - 360 gph at 300 psi

Detergent solutions are metered into the feedwater at any required rate. This unit would be mounted on a trailer which allows it to be moved at will.

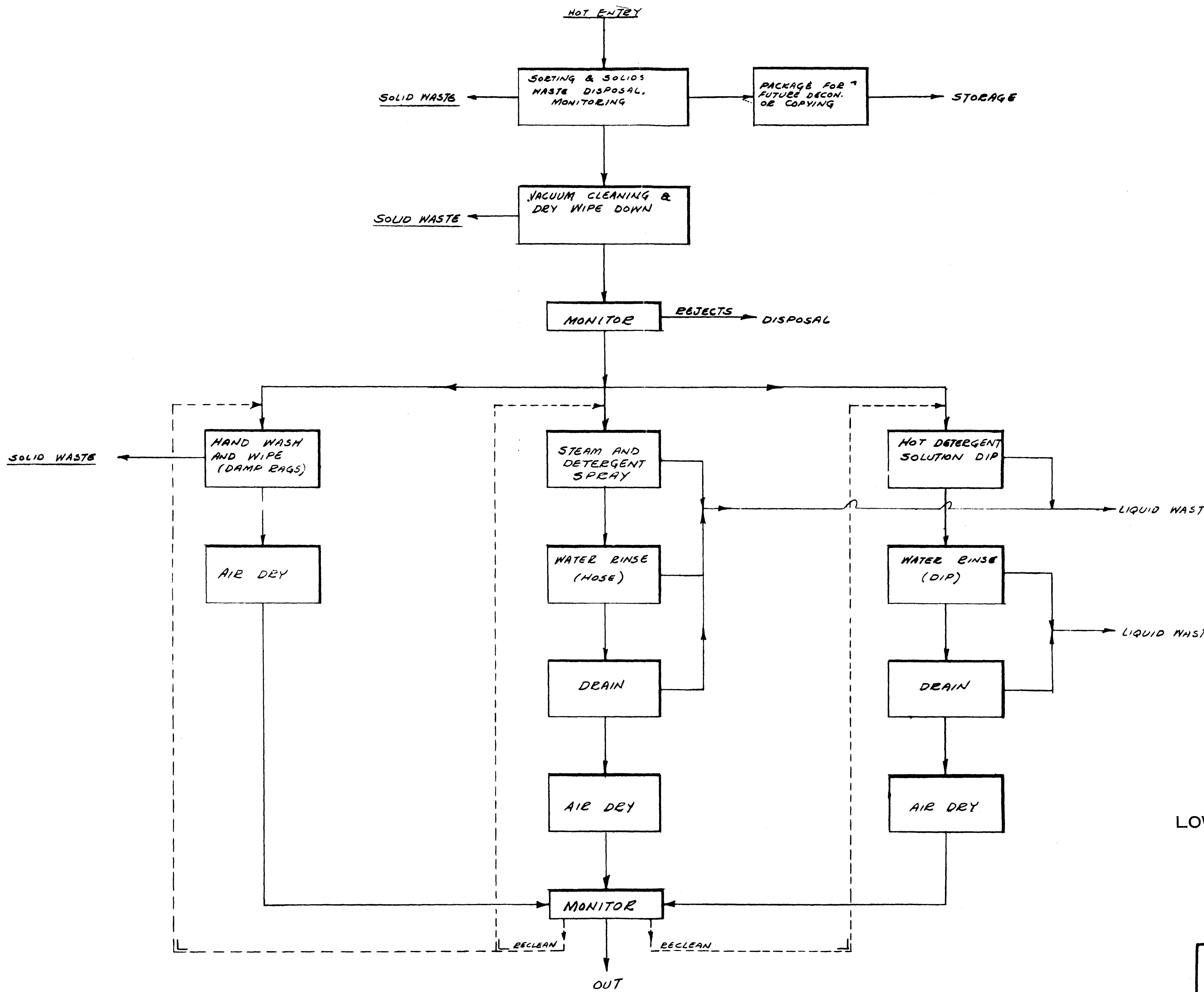
Water supply for field operations would be provided by a 1,000 gallon tank mounted on a truck, which would also serve as the vehicle for towing the trailer. In addition to the steam cleaning unit, the LPG tanks and a centrifugal pump would be mounted on the trailer. The centrifugal pump, with a capacity of approximately 400 gph at 40 psi would provide a continous positive water supply to the steam cleaning unit. Thus, with the exception of the electrical supply, this system was self-contained, facilitating field operation.

b. Low Level Decontamination Building (Figure IV-3)

The building would be fabricated from wood with the interior floor and walls lined with stainless steel sheets to a minimum height of eight feet. The floor sheets would be pitched downward from both sides toward the middle to permit drainage. A grating would be installed to permit a level, water free, working surface while allowing drainage to the pitched floor below. A simple anti-chamber would be provided at each end of the building to facilitate monitoring and ventilation control. The flow of services in the building is shown in Figure IV-3.

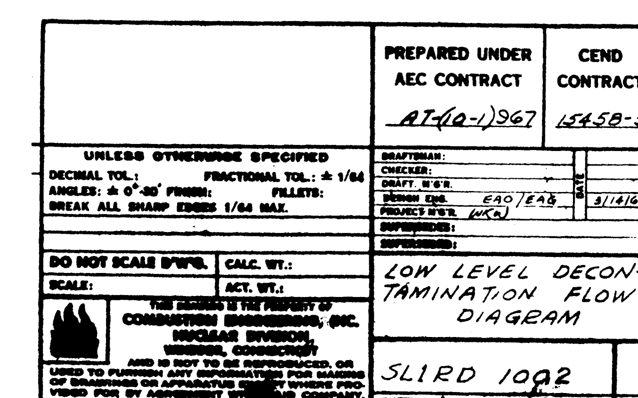
c. Description of Crane and Boom (Figures IV-4, IV-5, and IV-6)

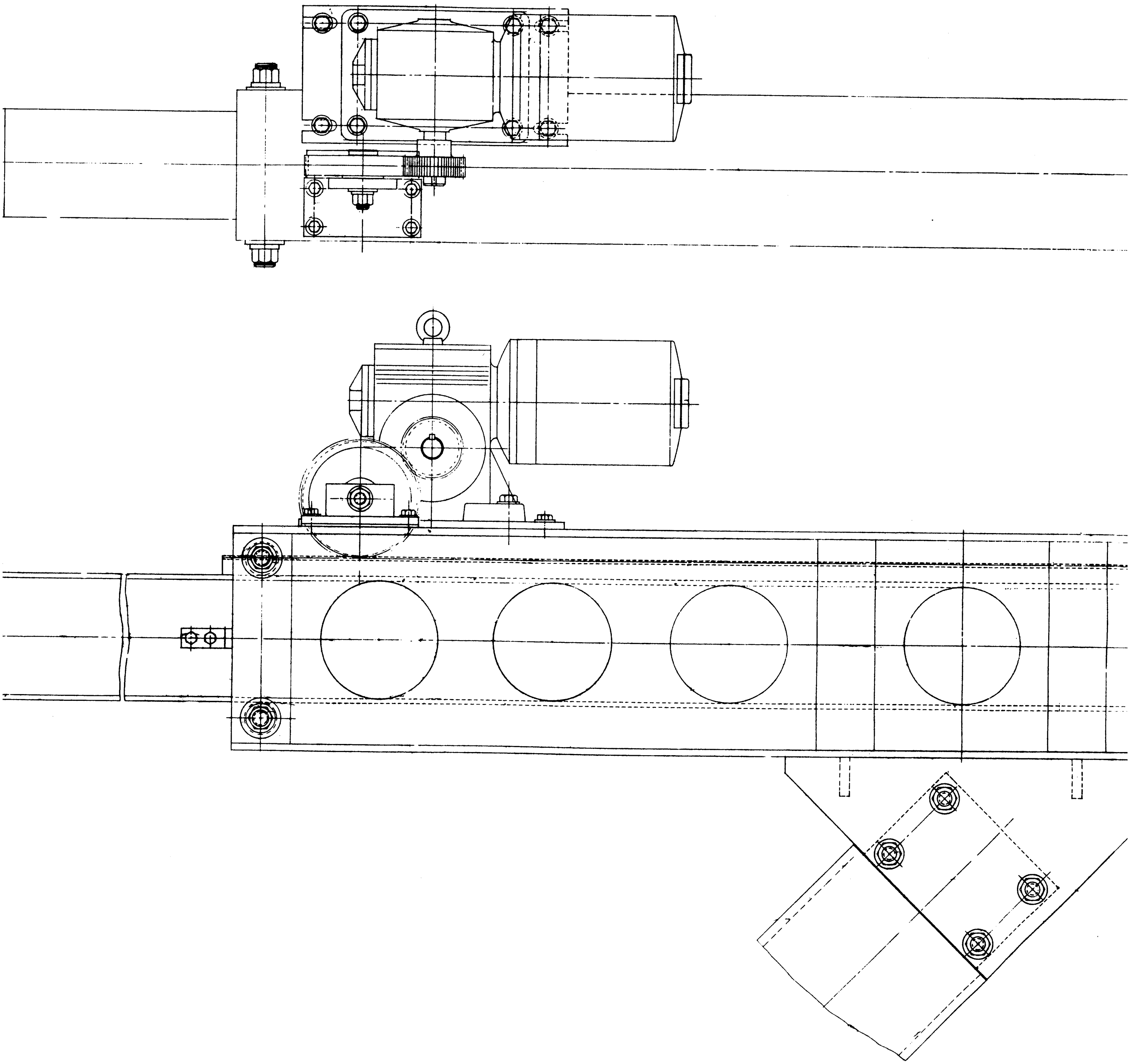
Operations to date have been conducted with a five ton capacity model Austin-Western hy-loader hydraulic crane. This is a gasoline powered crane which drives on four pneumatic tires and is equipped with hydraulic operated outriggers for greater stability. The drivers are shielded by 1-1/2 inch lead housing specially constructed over the cab.

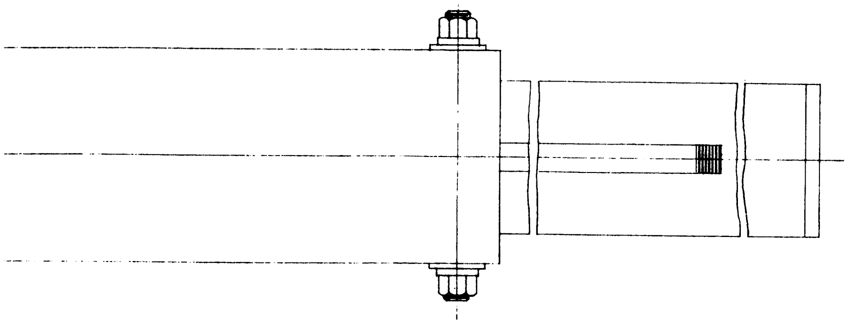


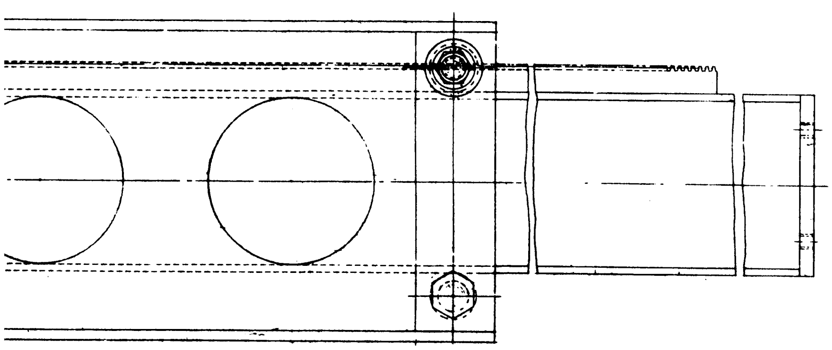
LOW LEVEL DECONTAMINATION FLOW CHART

FIGURE IV-3





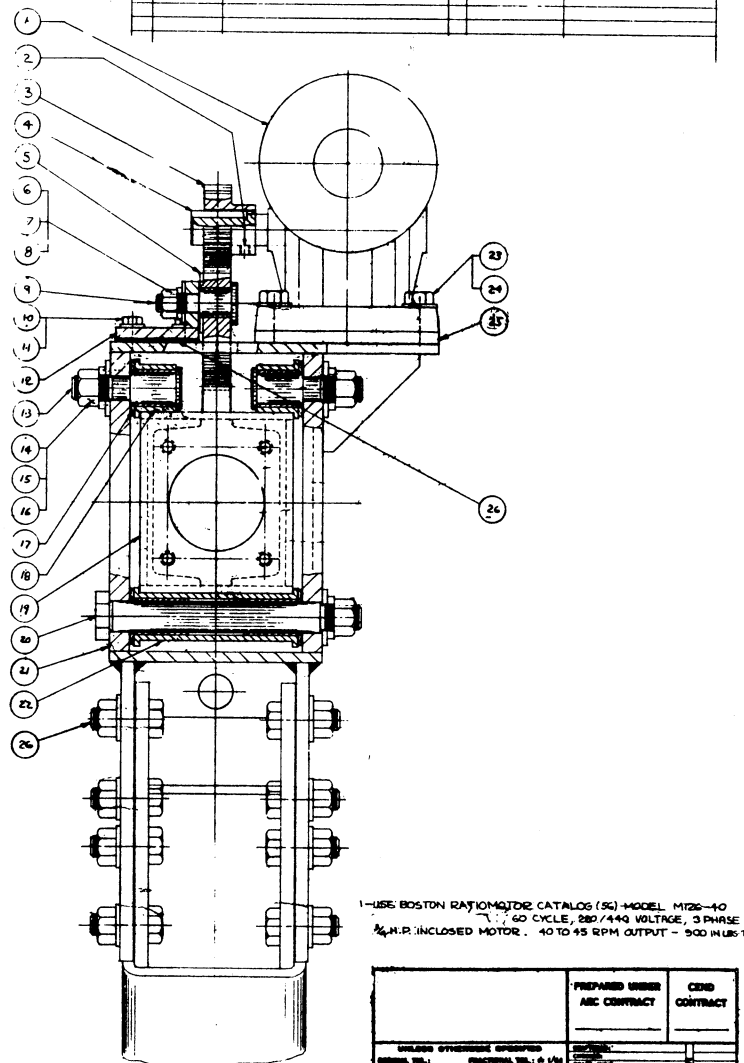




BILL OF MATERIALS

QUANTITIES ARE FOR UNITS

ITEM NO.	PIECE NUMBER	NAME	NO. REQ.	MATERIAL	REMARKS
1		RATIOMOTOR	1		SEE NOTE # 1
2		SOCKET HEAD SET SCREW	1	C'STEEL	3/8"-16NC x 3/8 LONG
3		DRIVE GEAR (12 PITCH-56 TEET)	1	C'STEEL	SEE SHEET # 2
4		1/4 SQ KEY (2" LONG)	1	C'STEEL	USE STD KEY STOCK
5		DRIVE GEAR (12 PITCH-72 TEETH	1	C'STEEL	SEE SHEET # 2
6		NUT	1	"	5/8-11NC-2 (REGULAR)
7		WASHER	1	"	FOR 5/8 THD (MEDIUM)
8		LOCKWASHER	1	"	FOR 5/8 THD (MEDIUM)
9		STUD - 72T GEAR	1		SEE SHEET # 2
10		BOLT - REGULAR SEMI-FINISHED HEX	4	C'STEEL	3/8 -16NC-2 x 1" LONG
11		LOCKWASHER (MEDIUM)		C'STEEL	3/8 DIA BOLT
12		BRACKET WELDMENT - GEAR SUPPORT	1	C'STEEL	SEE SHEET # 2
13		STUD - ROLLER	4		SEE SHEET # 2
14		NUT - SEMI-FINISHED HEX (HEAVY)	7	C'STEEL	1"- 8NC-2
15		WASHER (HEAVY)	7	"	FOR 1 THD
16		LOCKWASHER (HEAVY)	7	"	FOR 1 THD
17		THRUST WASHER	8		SEE SHEET # 2
18		ROLLER	6		SEE SHEET # 2
19		TRAVELING BEAM	1		SEE SHEET # 2
20		STUD - ROLLER FRONT LOWER	2		SEE SHEET # 2
21		SUPPORT STRUCTURE	1		SEE SHEET # 2
22		ROLLER - FRONT LOWER	1		SEE SHEET # 2
23		BOLT	4		1/2-13 UNC-2 x 1 1/4 LONG
24		LOCKWASHER	4		FOR 1/2 DIA BOLT
25		BASE PLATE	1		SEE SHEET # 2
26		HARRDENED BOLT & NUTS	8	C'STEEL, HARDENE[illegible]	1" DIA x 2 1/2 ALLEN OR EQUAL
27					
28					



1—USE BOSTON RATIOMOTOR CATALOG (56) MODEL MT26-40
60 CYCLE, 220/440 VOLTAGE, 3 PHASE
3/4 H.P. INCLOSED MOTOR. 40 TO 45 RPM OUTPUT – 900 IN LBS

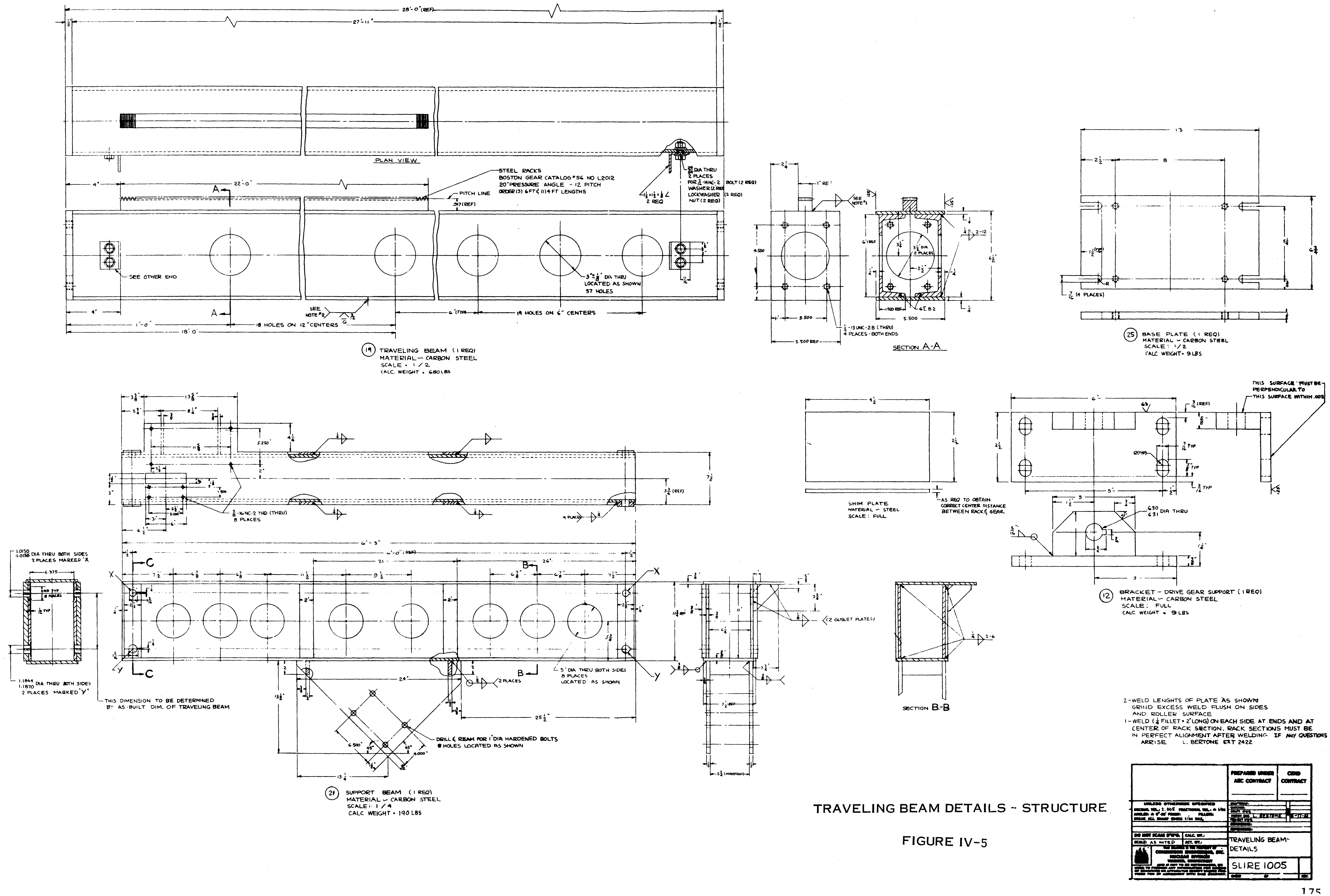
PREPARED UNDER AEC CONTRACT

TRAVELING BEAM ASSY

SLIRJ 1004

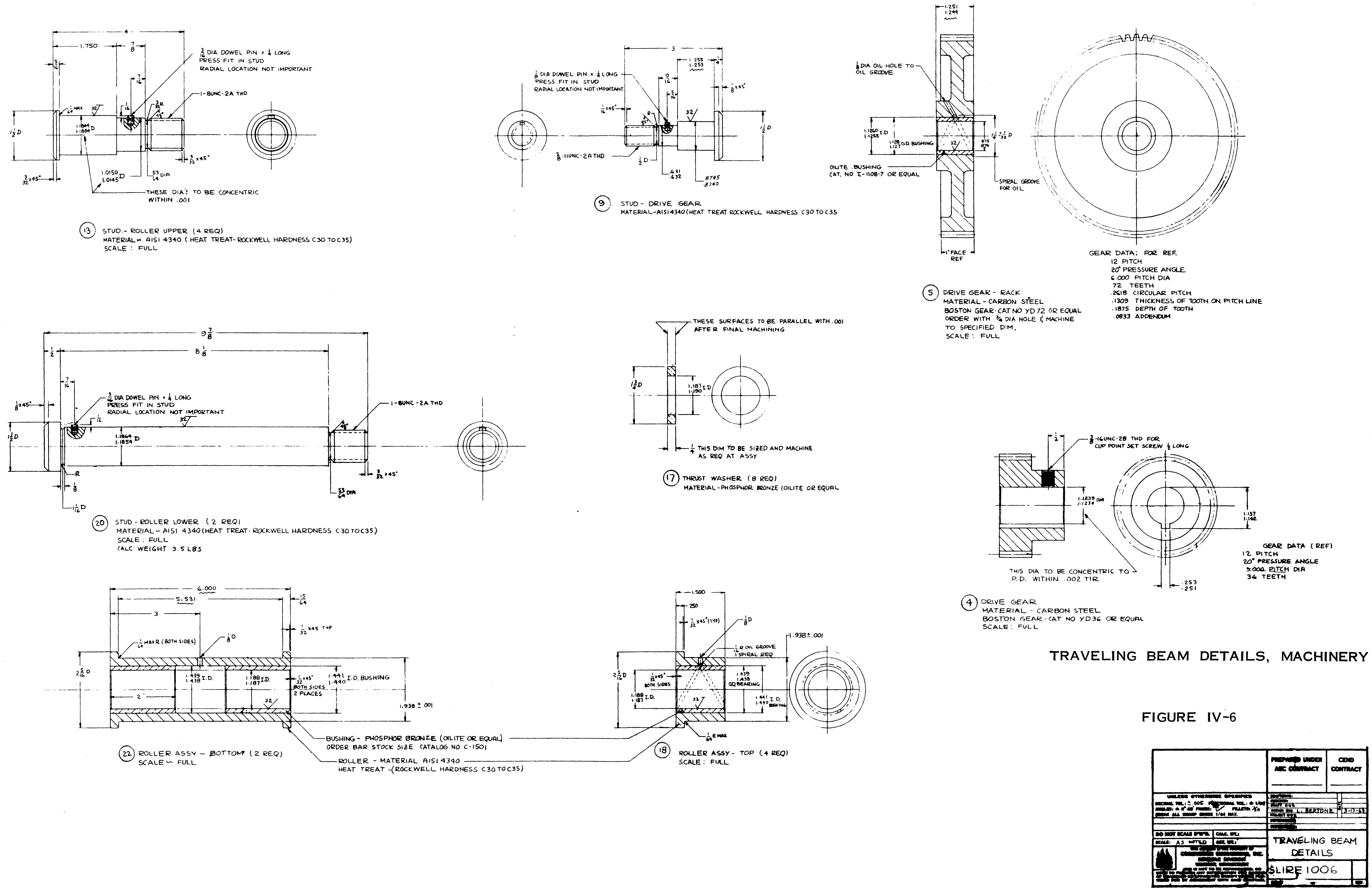
TRAVELING BEAM ASSEMBLY

FIGURE IV-4



TRAVELING BEAM DETAILS - STRUCTURE

FIGURE IV-5



TRAVELING BEAM DETAILS, MACHINERY

FIGURE IV-6

It has a hydraulic boom which elevates to 65° and telescopes out eight feet. The boom length can be varied from ten feet to 35 feet by use of interchangeable boom sections. The capacity varies between one and five tons, depending on boom position. This crane is suitable for all planned decontamination operations except lifting heavy objects such as shield blocks or machinery off the fan floor or operating floor.

It was planned to procure a second hydraulic crane which would meet all the operation requirements including the additional lift capacity necessary for lifting heavy objects from the reactor building. While one crane was engaged in an actual entry, the other would be used at a mock-up for developing techniques and training the crews for the next operations. The two cranes and crews would alternate on operations and would therefore minimize delays due to training. Each crane would have a 1,000 pound capacity horizontal motor driven beam (Figure IV-4).

The traveling boom (Figures IV-4, IV-5, and IV-6) is a motor operated box beam which is supported horizontally at the end of the hydraulic crane boom when the boom is elevated to a 45° angle.

The purpose of the boom is to provide a means of reaching into the reactor operating room and fan room to support or lift various pieces of equipment to be used in the remote decontamination.

The boom is equipped with a constant speed motor and rack and pinion drive which will drive it in or out at 30 feet per minute. When fully extended it will reach horizontally 24 feet 6 inches from its support point on the crane. This, in combination with telescoping and panning features, will provide sufficient motions to reach into the reactor building area of high contamination, i.e., an 18 foot diameter circle about the center of the reactor. The load capacity of the boom is greater than the supporting hydraulic crane. The capacity of the system is as follows:

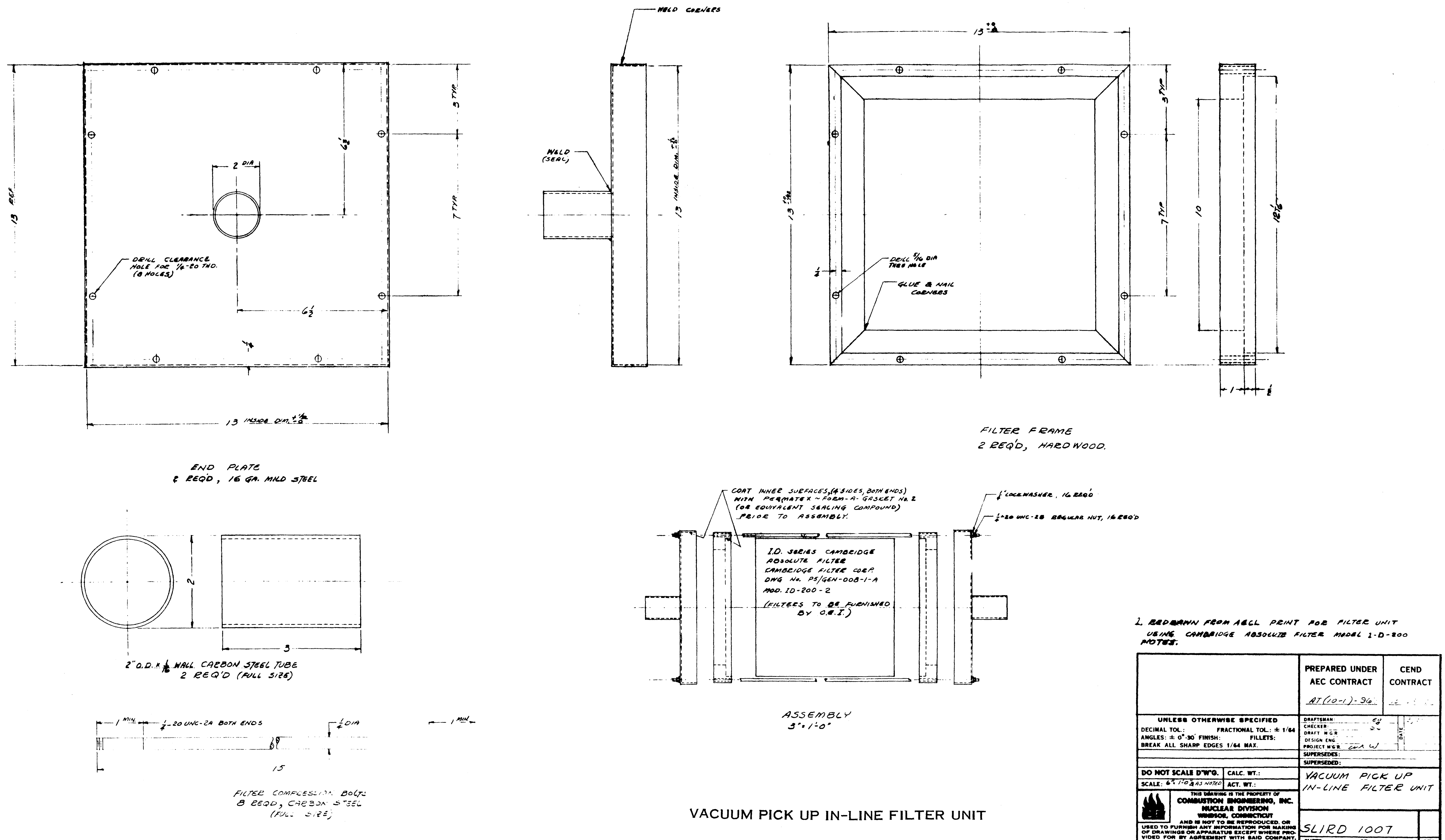
(1) Lift capacity at end of the boom when fully extended telescoped is 1,000 pounds.

(2) Maximum allowable moment at base of the telescoping boom due to a load on the boom is 600,000 inch pounds.

The boom motor drive is operated from a control box at the base of the telescoping boom. It requires an external 440 volt three phase power supply. Limit switches on the traveling boom prevent over extension.

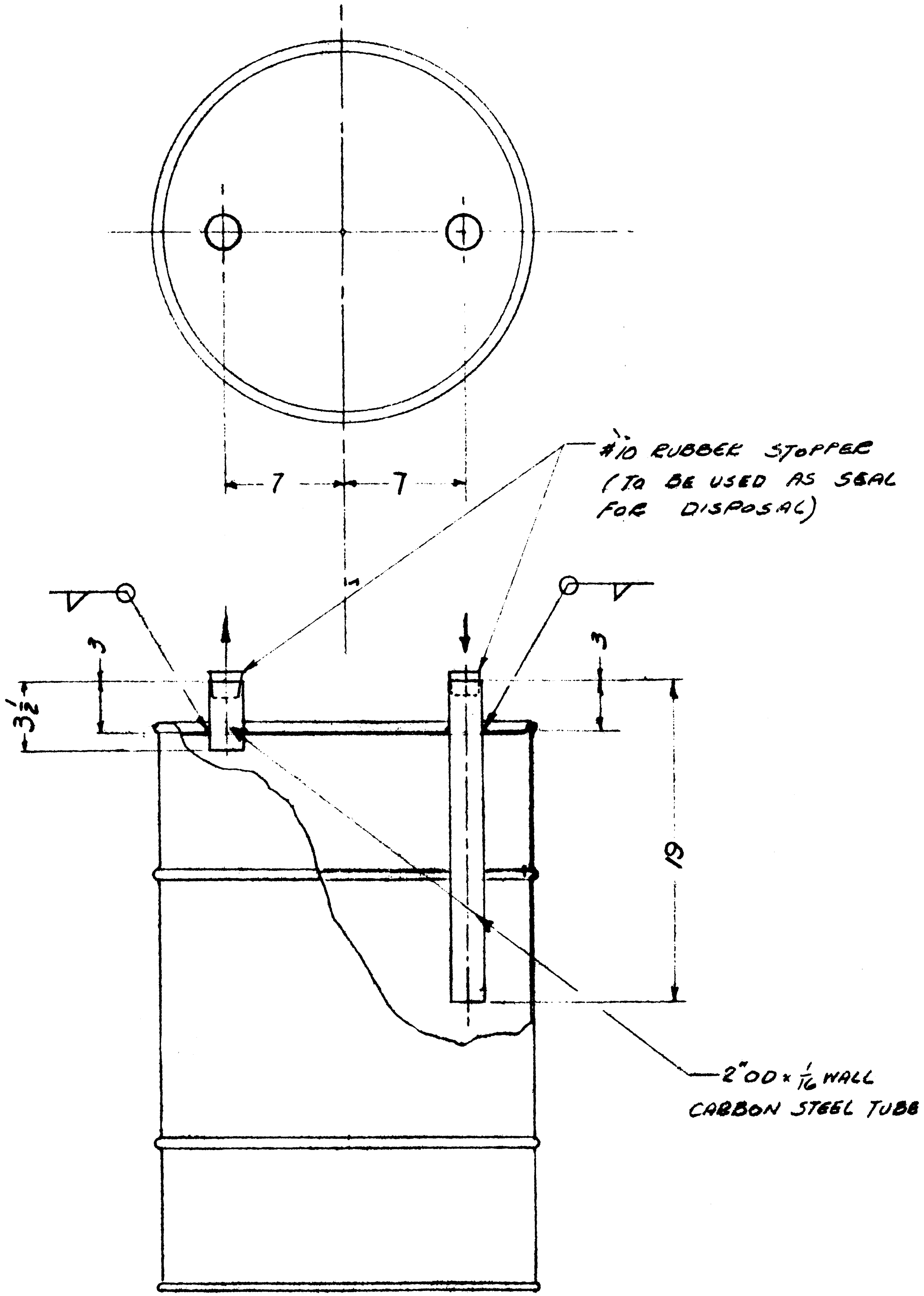
d. Filter Vacuum System (Figures IV-7, IV-8, IV-9 and IV-10)

The filtered vacuum system was designed to provide a method of collection and disposal of low level contaminated particles. This unit would provide



VACUUM PICK UP IN-LINE FILTER UNIT

FIGURE IV-7



BAFFLE FOR VACUUM

DECONTAMINATION SYSTEM

FIGURE IV-8

3. DRUM SHOWN IS STANDARD 55 GAL. DRUM.
2. DRUM EXTERIOR TO BE COATED WITH 2 COATS RUST INHIB. PAINT.
1. ALL OPENINGS OTHER THAN THOSE SHOWN ARE TO BE SEALED BY WELDING PATCHES, OR THREADED PLUGS WITH SEALING COMPOUND

NOTES.

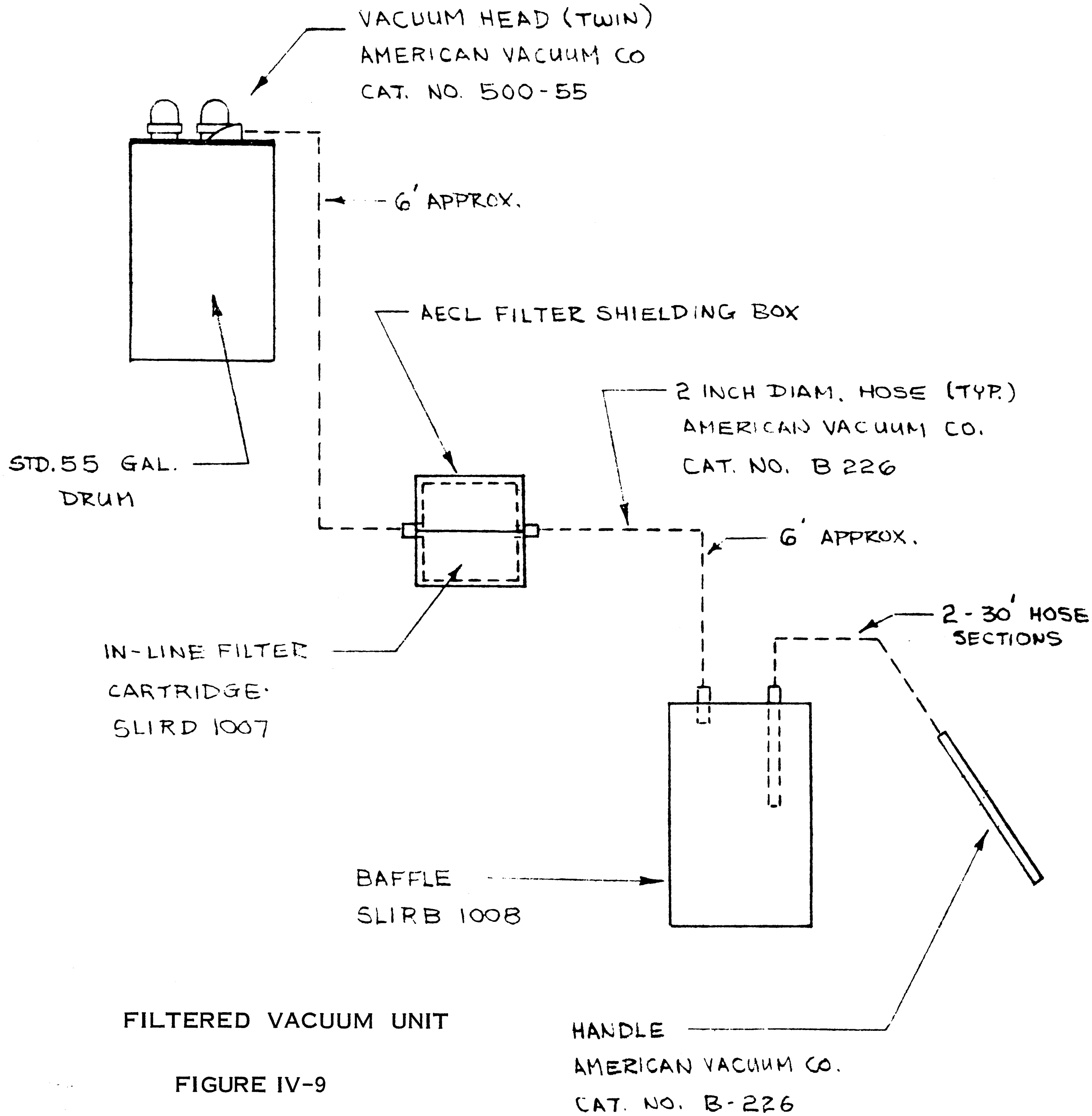
	PREPARED UNDER AEC CONTRACT	CEND CONTRACT
UNLESS OTHERWISE SPECIFIED DECIMAL TOL.: FRACTIONAL TOL.: ± 1/8 (~~1/64~~) ANGLES: ± 0°-30 FINISH: FILLETS: BREAK ALL SHARP EDGES 1/64 MAX.	DRAFTSMAN: 3/22/60 CHECKER: DRAFT. M'G'R. DESIGN ENG. EOG 3/23/61 PROJECT M'G'R. WKW	
	SUPERSEDES:	
	SUPERSEDED:	
DO NOT SCALE D'W'G. / CALC. WT.:	BAFFLE UNIT FOR VACUUM DECON. SYSTEM	
SCALE: 1½" = 1'-0 / ACT. WT.:		
THIS DRAWING IS THE PROPERTY OF COMBUSTION ENGINEERING, INC. NUCLEAR DIVISION WINDSOR, CONNECTICUT AND IS NOT TO BE REPRODUCED OR USED TO FURNISH ANY INFORMATION FOR MAKING OF DRAWINGS OR APPARATUS EXCEPT WHERE PROVIDED FOR BY AGREEMENT WITH SAID COMPANY.	SLIDE 1008 SHEET OF	REV.

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

CONTRACT NO.

SUBJECT: SL-1 RECOVERY-FILTERED VACUUM SYSTEM

CALCULATION NO.
DWG. NO. SL1RA 1035
SHEET ___ OF ___
DATE 5/1/61 BY EAO
CHECK DATE ___ BY WKW



FILTERED VACUUM UNIT

FIGURE IV-9

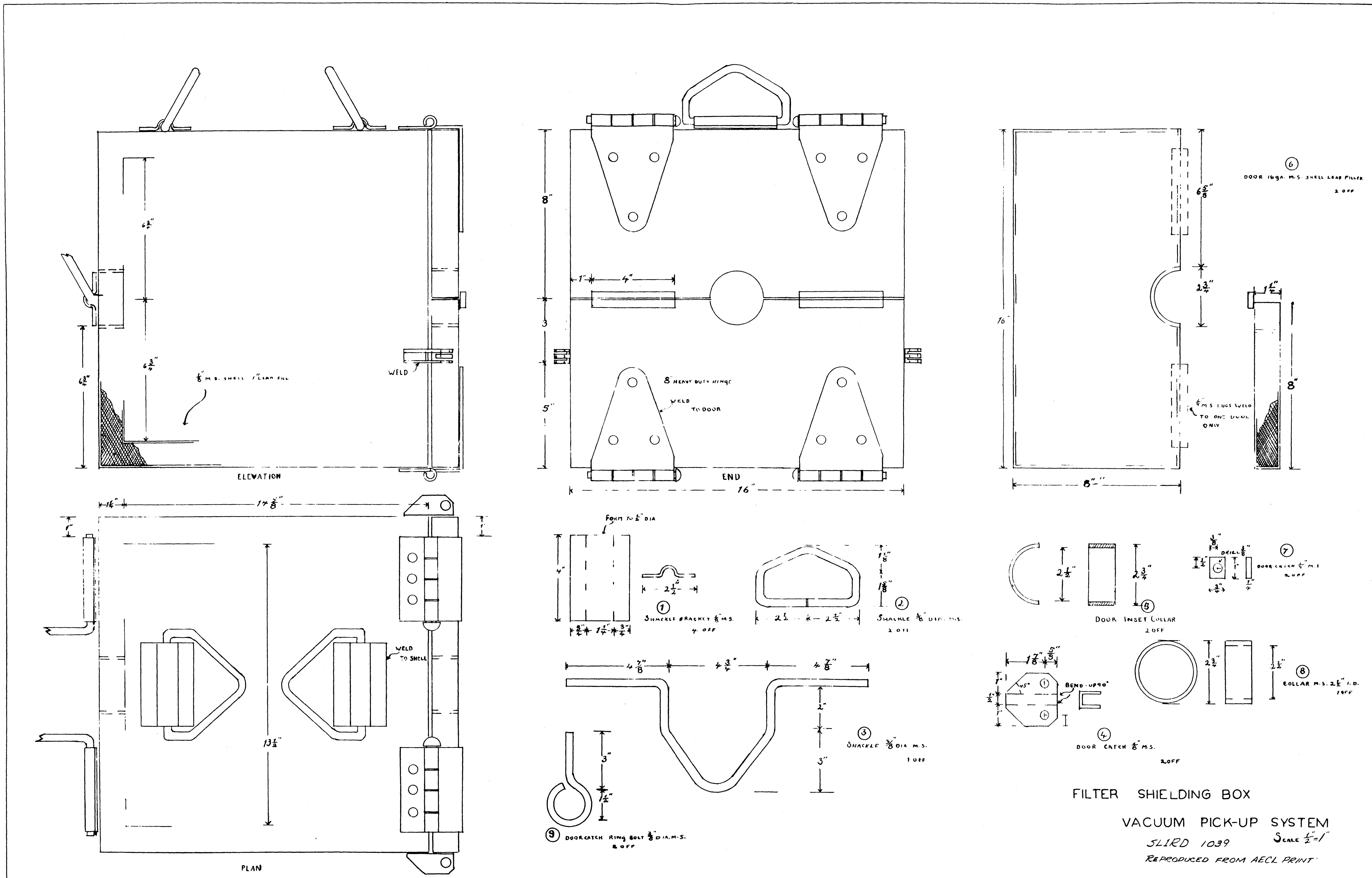

ELEVATION
WELD
END
8" HEAVY DUTY HINGE
WELD TO DOOR
PLAN
WELD TO SHELL
FORM TO ½" DIA
SHACKLE BRACKET ⅛" M.S. 4 OFF
DOOR INSET COLLAR 2 OFF
DOOR CATCH ⅛" M.S. 2 OFF
BEND-UP 90°
COLLAR M.S. 2½" I.D. 1 OFF
DOORCATCH RING BOLT ⅜" DIA. M.S. 2 OFF
FILTER SHIELDING BOX
VACUUM PICK-UP SYSTEM
SLIRD 1039
SCALE ½"=1"
REPRODUCED FROM AECL PRINT

FIGURE IV-10

vacuum service for the following decontamination operations in addition to road decontamination:

(1) Low level decontamination building

(2) Building decontamination

The vacuum source would be a standard industrial vacuum head which mounts on a 55 gallon drum. This unit, is available as a federal stock item and is powered by two 115 volt, 1-1/2 horsepower motors. This unit has a capacity of 4825 cfm and a static head of 62 inches H_2O.

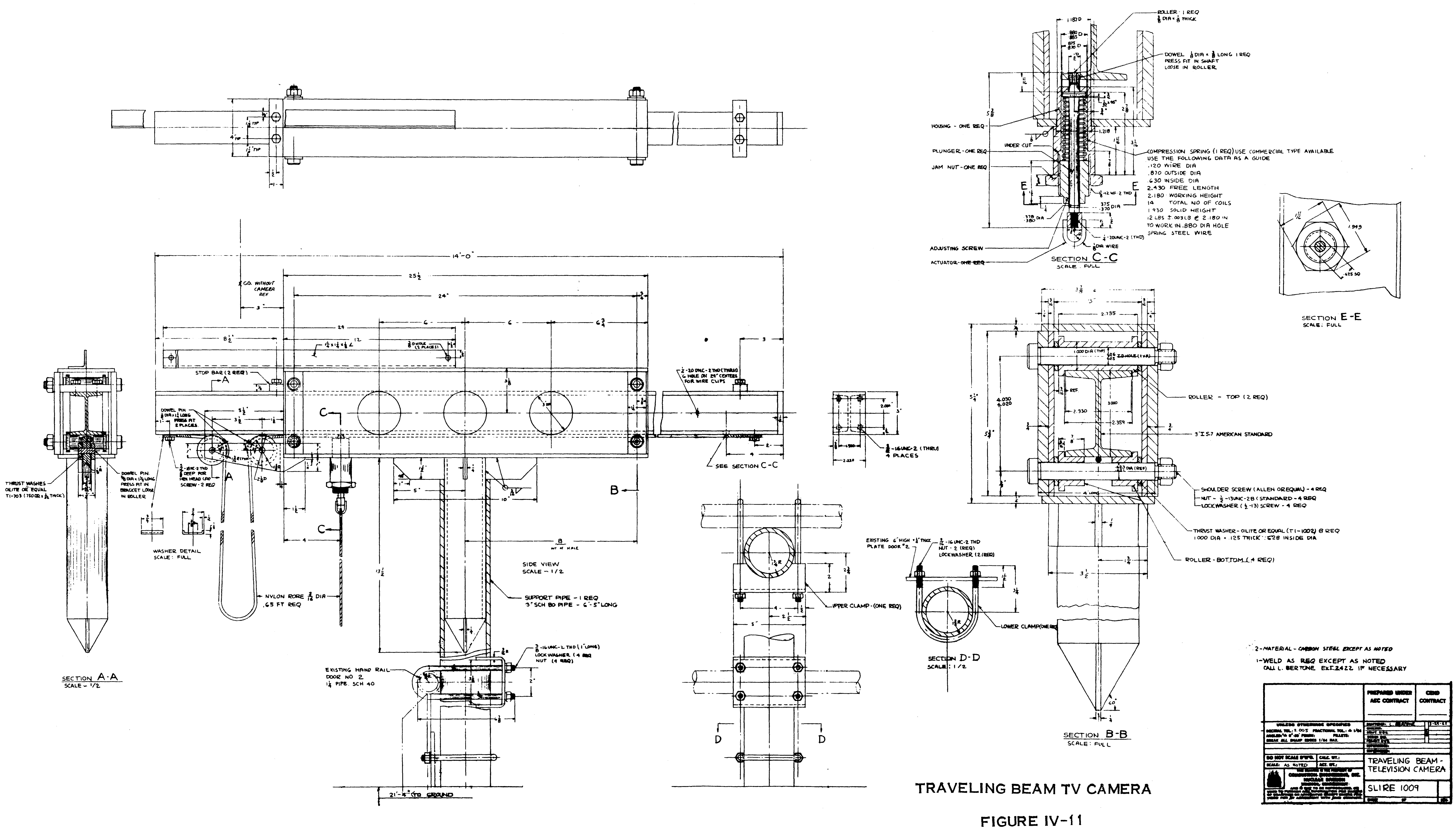
Initial separation and collection of contaminated particles would be accomplished by means of the baffle unit (Figure IV-8). Reduced air velocity in this unit would allow the major portion of the particles carried by the air to drop and collect at the bottom of the unit. The baffle unit, with its inlet and outlet closed with rubber plugs, would be used as a disposal container for the material collected.

The in-line filter unit (Figure IV-7) would be provided between the vacuum unit and the baffle unit to collect small particles which might pass through the baffle unit. The use of an "absolute" filter (99.95 percent effective on 0.3 micron particles) would prevent contamination of the vacuum unit and/or spread of contamination to the air from the vacuum exhaust. The filter having a glass fibre filter media and corrugated aluminum separators, is design for operation under conditions of 100% humidity. It should not be used,however, for wet pick-up operations where entrained water could be present in the air passing through the filter.

A filter shielding box which was on loan from AECL allowed remote disposal of filter cartridges. The baffle unit, the filter inlet and outlet could be plugged with rubber stoppers prior to disposal.

e. Remote Controlled Closed Circuit Television System (Figure IV-11)

The television camera assembly would consist of a radiation resistant television camera, with a remote controlled focus mounted on a remote controlled pan and tilt mechanism. It was planned to mount the camera assembly on a cantilever beam (Fig. IV-11) which protruded into the operating room through entry door No. 2. A bracket would be bolted to the hand rail on the stair landing outside the entry door. It would then be possible to lift the beam, with the camera assembly bolted to one end of it and remotely install it on the bracket using the Austin-Western or a similar crane. Once the beam is in place, a locking device could be disengaged by pulling a lanyard. The traveling section would be manually driven into the operating room by a man at ground level pulling on a nylon line which is suspended from the beam. The camera could then be oriented using the remote controlled pan and tilt mechanism.



TRAVELING BEAM TV CAMERA

FIGURE IV-11

In the event that maintenance would be required on the television camera the traveling beam could be withdrawn and locked in place again by a man at ground level. Then the entire assembly would be remotely engaged and removed by the crane.

The beam was designed to support 125 pounds when extended to twelve feet.

f. High Level Vehicle Decontamination Pan (Figure IV-12)

The pan would be located under the freight doors of the reactor building. A base for the platform would be laid as follows: A ten inch deep gravel bed should be laid and rolled smooth; a wooden surface consisting of two layers of 2 x 12 planks (one layer being perpendicular to the other and nailed together) should be placed on the gravel; the decontamination pan would lay on the wooden surface and would be fastened to the wood by lag screws. Two drain pipes have been located to provide drainage.

g. Shield Plugs, Control Rod Nozzle (Figure IV-13)

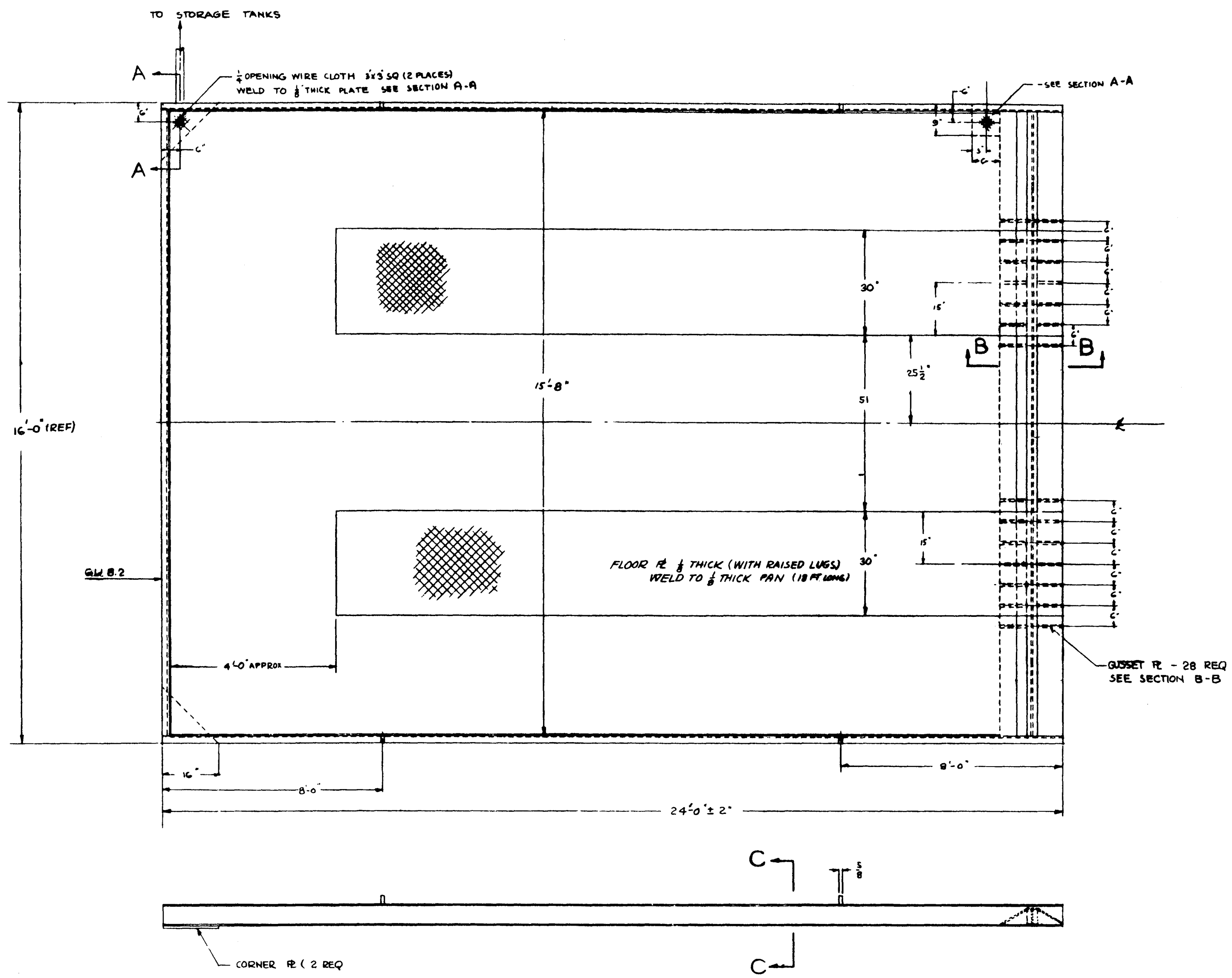
Two steel and lead plugs with lifting eyes are provided for insertion in ports No. 4 and No. 8. They provide shielding at head level. The other four plugs are designed to fit over the racks and shafts which protrude from the other ports. Their effective shielding is therefore less effective, however, they still prevent objects from falling into the ports.

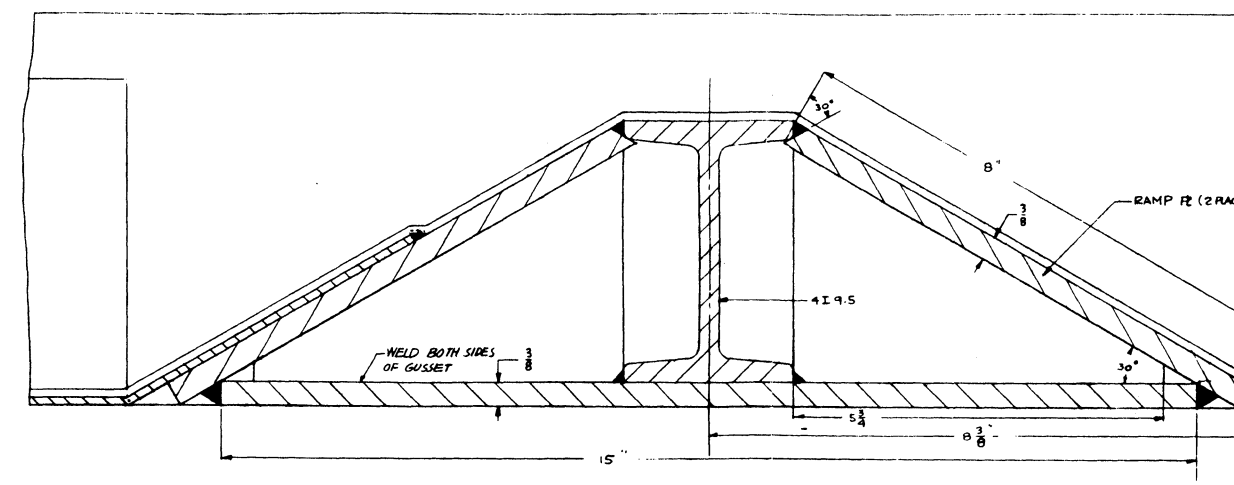
h. Temporary Waste Disposal Area (Figures IV-14, IV-15, and IV-16)

The general layout of the waste disposal area is shown in SL1RA-1040 and SL1RA-1042. The area would have three pits, with room for a fourth, if required. The access road would extend into the area, allowing the use of heavy equipment. The whole area would be graded prior to excavating the pits. Enclosure of the area would be provided by a three-strand barbed wire fence. A gate with a lock would extend across the roadway allowing the area to be secured between entries. The fence would be marked at suitable intervals with radiation warning signs. The layout of the burial pits is shown in Fig. IV-15. The pits would be roofed over with removable covers, preventing rain or snow from entering the pit and preventing the spread of contaminated particles from the pits by wind. The pit would be lined with heavy plastic sheeting or with tar paper to limit soil slumping into the pit. The twelve foot width of the cover would then have to be increased to suit.

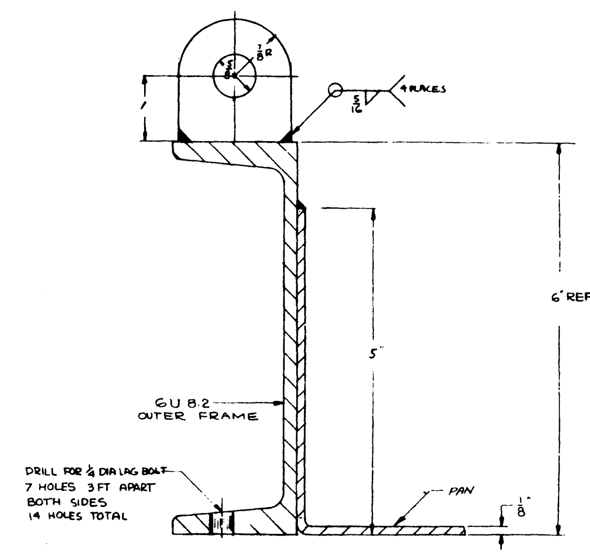
i. Twin Camera Shielding Box (Figure IV-17)

This is a one-half inch thick lead box with steel angle frame. It is designed to support two 16 mm Bell and Howell movie cameras with their electric drives with one pointed up and the other down. Previous camera entries over an unshielded head have shown that one-half inch of lead shielding is adequate to prevent fogging of the movie film. The

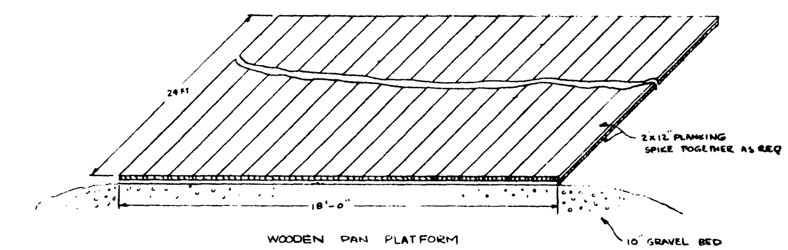




SECTION B-B
SCALE FULL



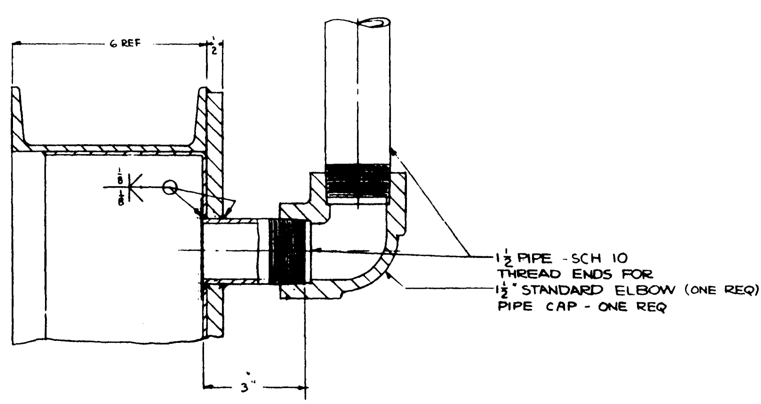
SECTION C-C
SCALE: FULL



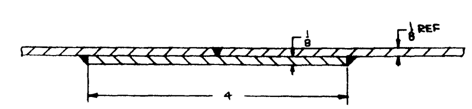
WOODEN PAN PLATFORM

VEHICLE DECONTAMINATION APRON

FIGURE IV-12



SECTION A-A
SCALE: 1/2



TYP SECTION FOR WELDING OF PAN SHEETS

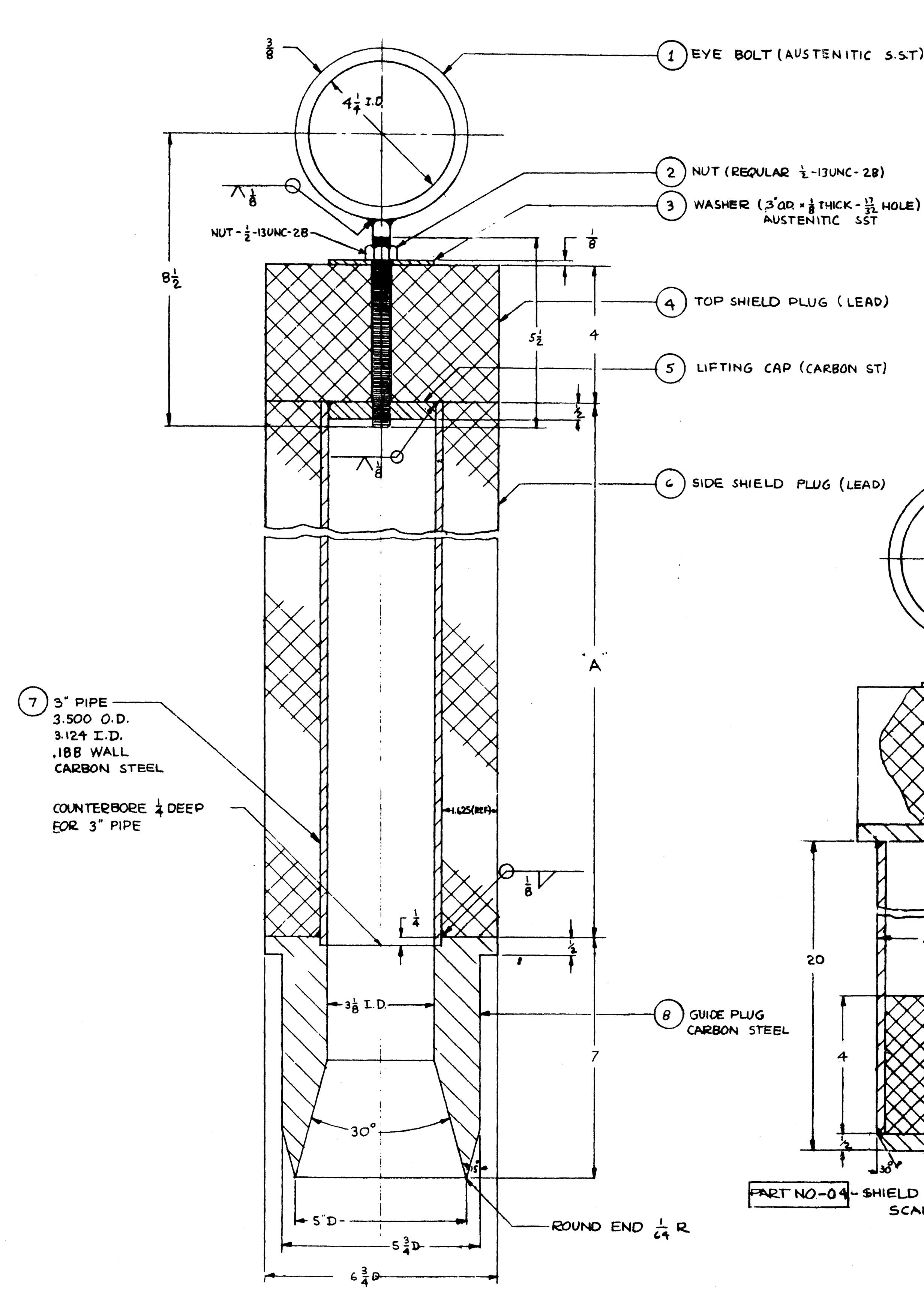
SCALE: FULL

4 - ALL WELDS TO BE CONTINUOUS
3 - PAN FLOOR SHEETS TO BE BUTT WELDED
2 - PAN MUST BE CAPABLE OF CONTAINING WATER WITHOUT LEAKAGE
1 - MAT'L - CARBON STEEL - COAT WITH RUST PREVENTIVE

PREPARED UNDER AEC CONTRACT	CEND CONTRACT
DRAFTSMAN: L. FERTONE 4-4-61	
DO NOT SCALE DWG.	CALC. WT.: 3627 LBS
SCALE: AS NOTED	ACT. WT.:
COMBUSTION ENGINEERING, INC. NUCLEAR DIVISION WINDSOR, CONNECTICUT	VEHICLE DECONTAMINATION PAN
	SLIRE 1011

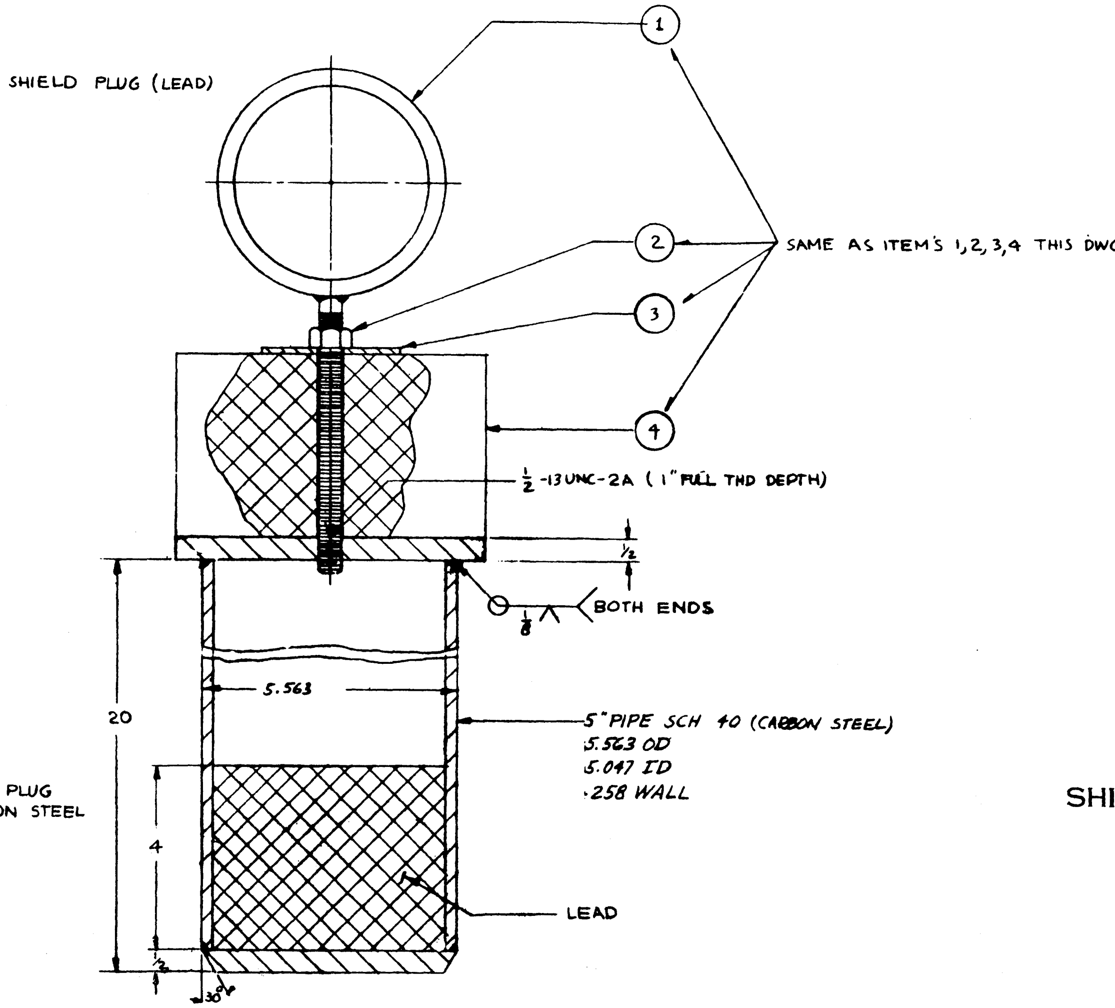
VEHICLE DECONTAMINATION APRON

FIGURE IV-12



SHIELD PLUG
SCALE ~ 1/2

PART NO	"A"	CONTROL ROD NO	TOTAL HEIGHT	TOTAL APPROX WEIGHT	NO REQ
01	24	7	41.250		1
02	20	1	37.250		1
03	5	9 & 3	22.250		2



PART NO-04 - SHIELD PLUG (CONTROL ROD NO'S 8 & 4) 2 REQ
SCALE ~ 1/2

SHIELD PLUG CONTROL ROD NOZZLE

FIGURE IV-13

	PREPARED UNDER AEC CONTRACT	CEND CONTRACT
UNLESS OTHERWISE SPECIFIED DECIMAL TOL.: FRACTIONAL TOL.: ± 1/64 ANGLES: ± 0°-30′ FINISH: FILLETS: BREAK ALL SHARP EDGES 1/64 MAX.	DRAFTSMAN: L. BERTONE 5/2/61 CHECKER: DRAFT M'G'R. [illegible] 5/3/61 DESIGN ENG. PROJECT M'G'R. SUPERSEDES: SUPERSEDED:	
DO NOT SCALE D'W'G. CALC. WT.: SCALE: ACT. WT.:	SHIELD PLUG CONTROL ROD NOZZLE	
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COMBUSTION ENGINEERING, INC.

NUCLEAR DIVISION

CONTRACT NO.____________

SUBJECT: SL-1 RECOVERY OPERATION - LOCATION OF TEMPORARY WASTE DISPOSAL AREA

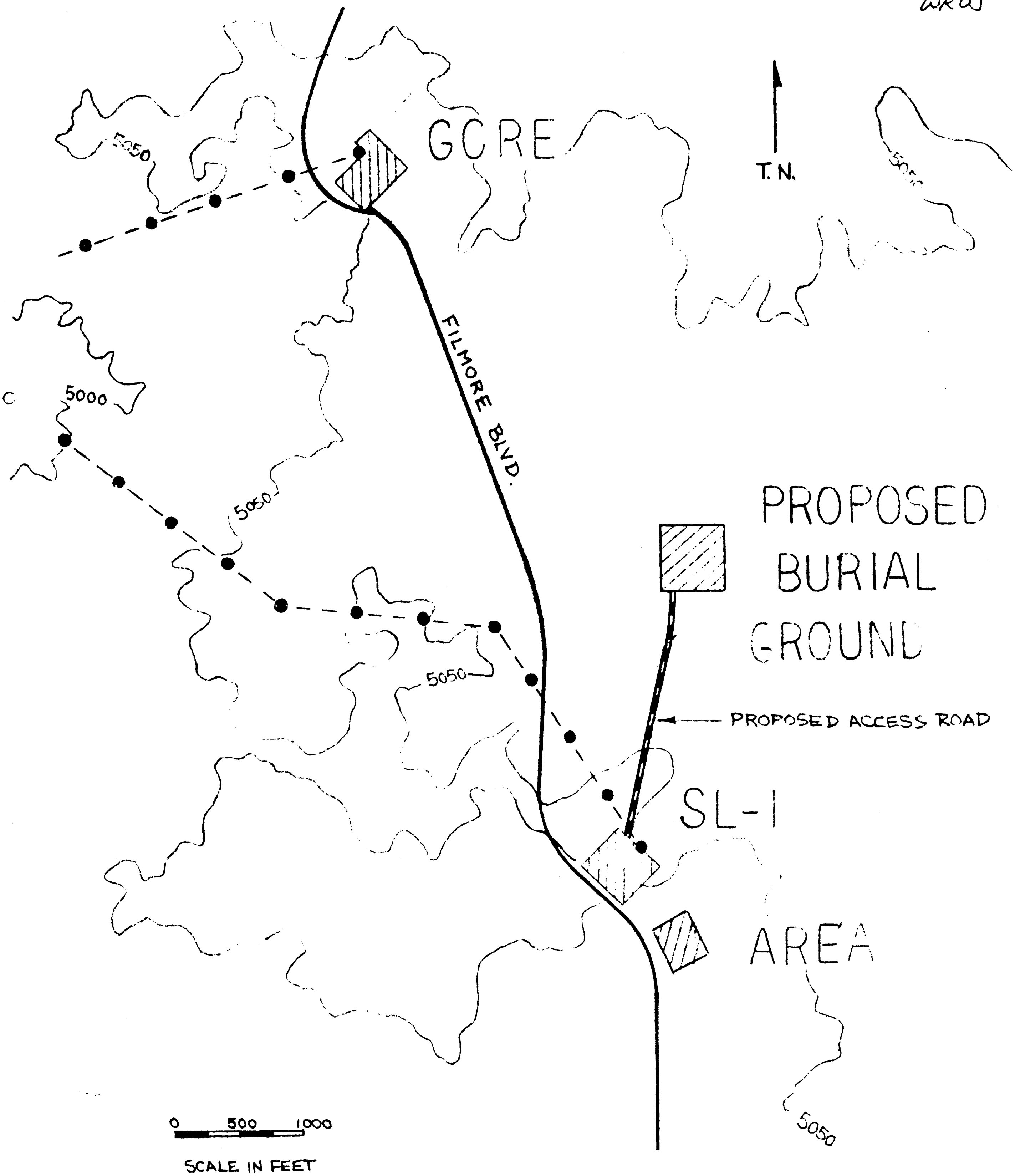
CALCULATION NO.____________

DWG. NO. SLIRA 1040

SHEET______ OF______

DATE 3/2/61 BY E.A.O

CHECK DATE______ BY WKW



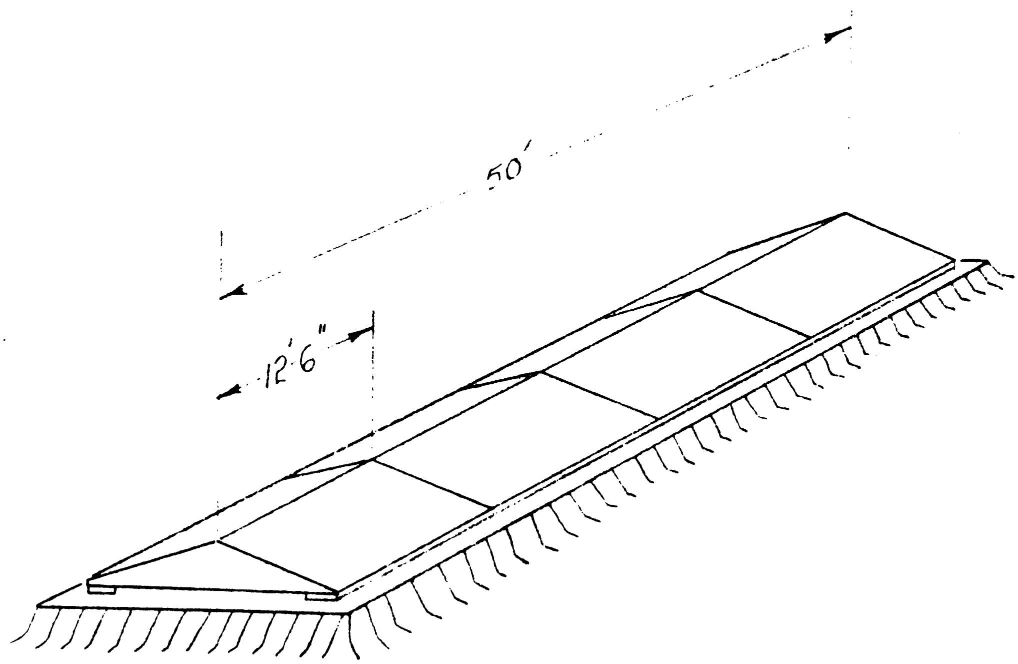
LOCATION OF TEMPORARY WASE DISPOSAL UNIT

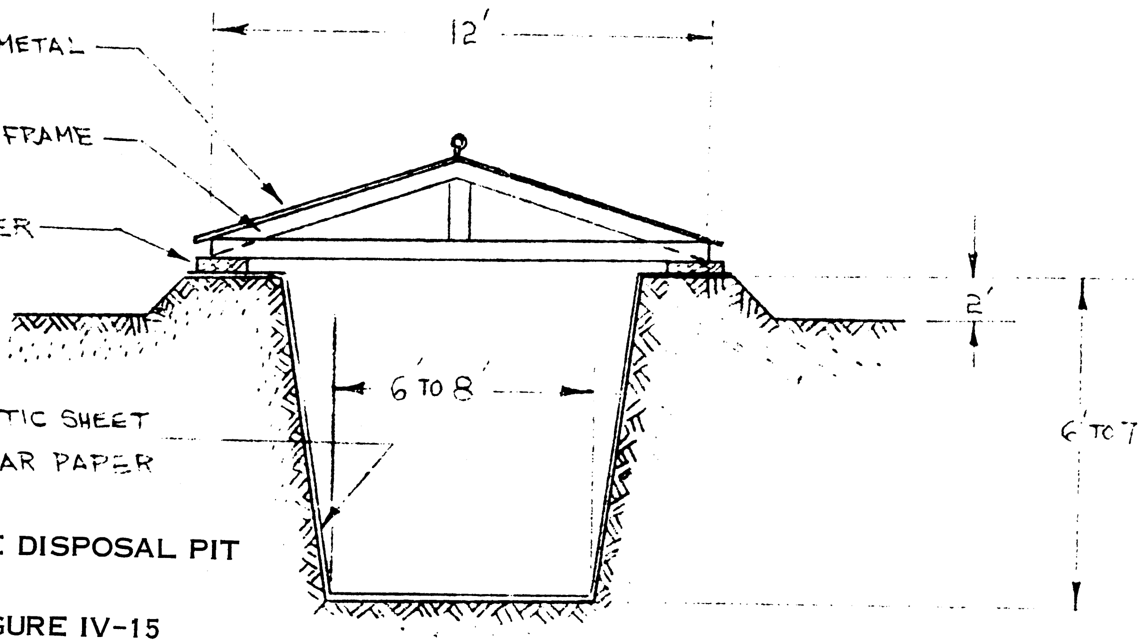
FIGURE IV-14

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION
CONTRACT NO.

SUBJECT SL-1 RECOVERY OPERATIONS - WASTE DISPOSAL PIT

CALCULATION NO.
DWG. NO. SLIRA 1041
SHEET ____ **OF** ____
DATE 3/2/61 **BY** E.A.O
CHECK DATE ____ **BY** ____





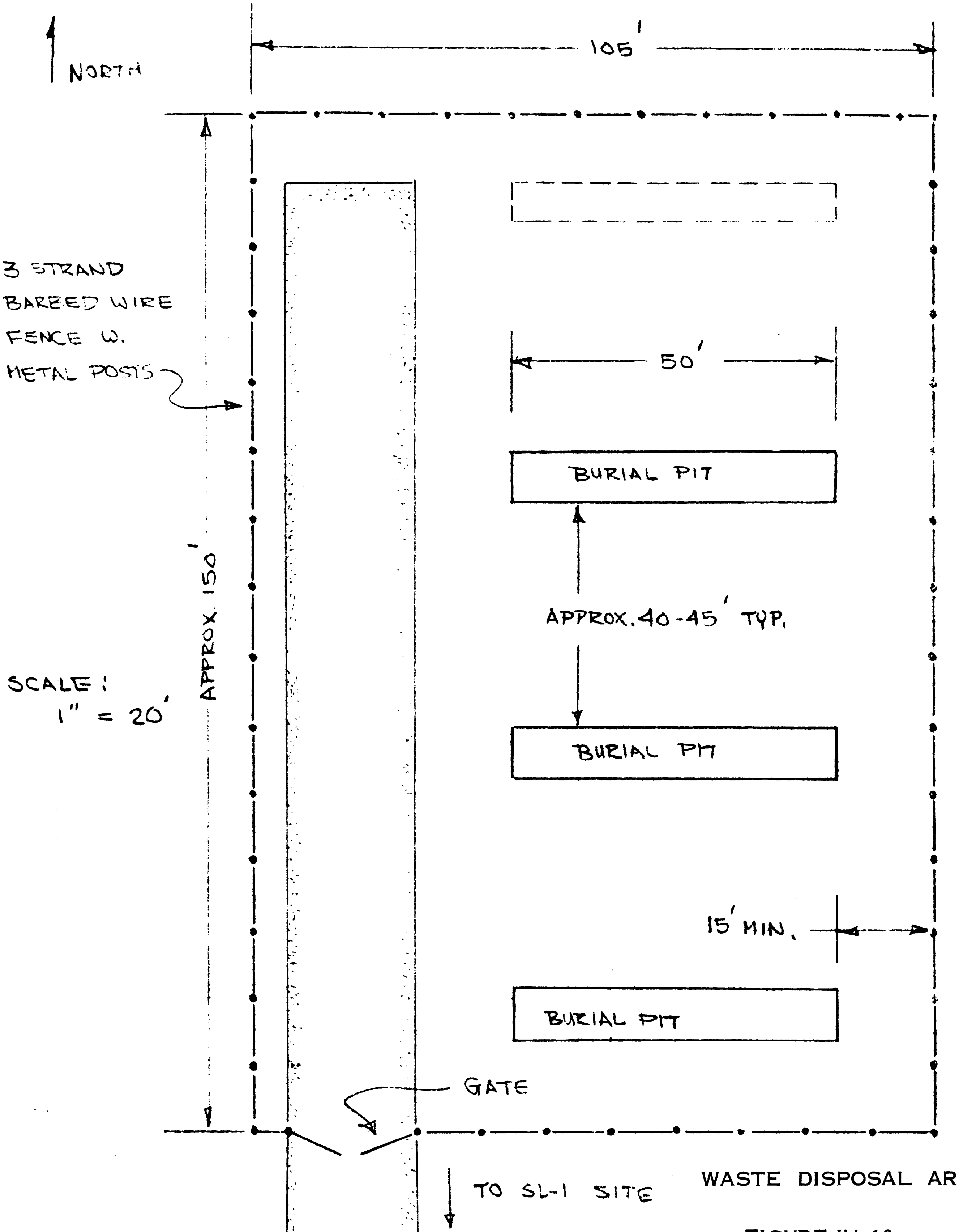
WASTE DISPOSAL PIT

FIGURE IV-15

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION
CONTRACT NO. ______

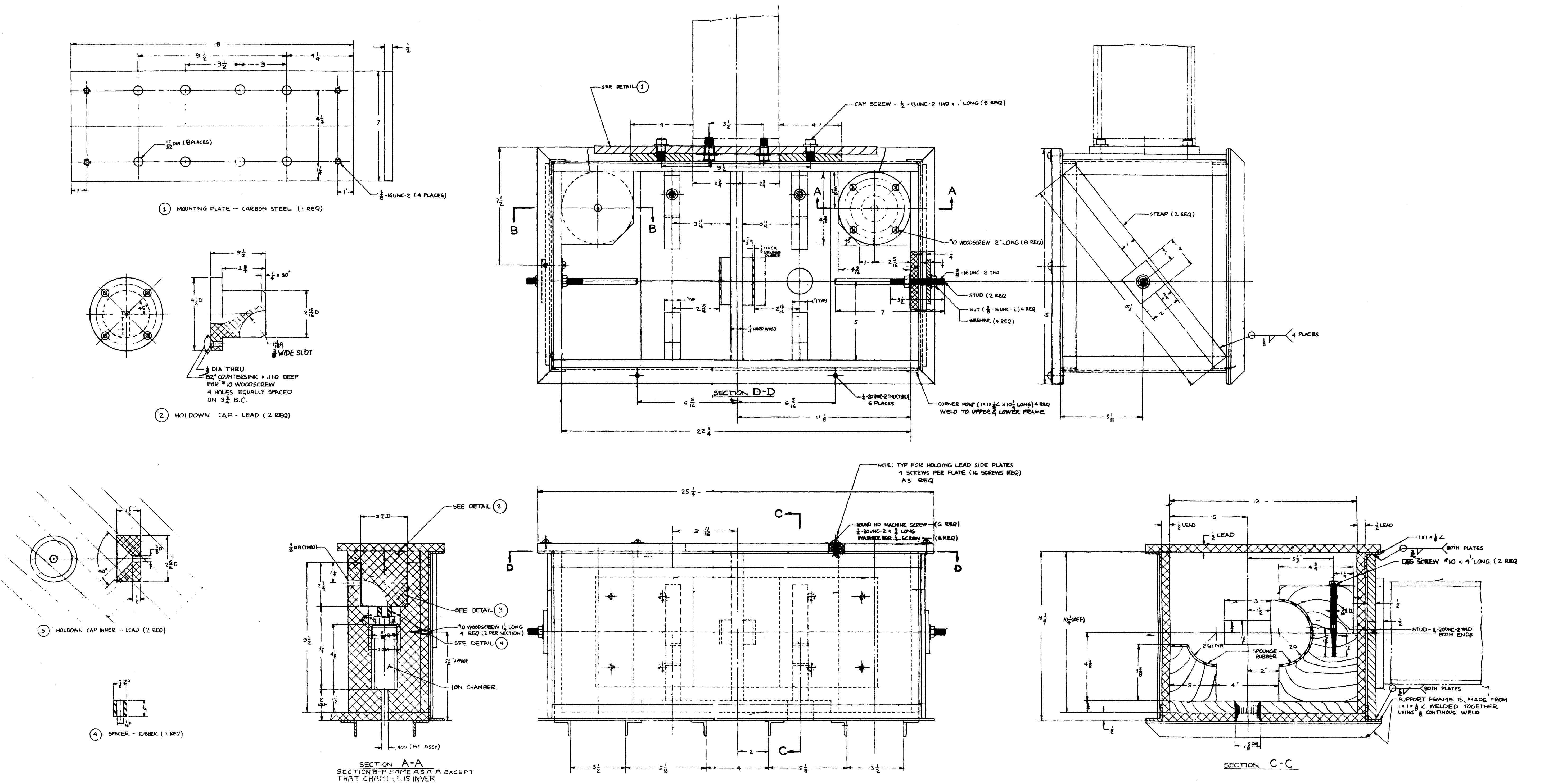
CALCULATION NO. ______
DWG. NO. SLIRA 1042
SHEET ____ OF ____
DATE 3/2/61 BY EAO
CHECK DATE ______ BY WKW

SUBJECT SL-1 RECOVERY OPERATION - TEMPORARY WASTE DISPOSAL AREA



WASTE DISPOSAL ARE

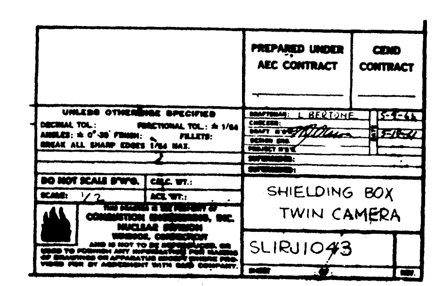
FIGURE IV-16



SHIELDING CAMERA – TWIN CAMERA

FIGURE IV-17

-USE GLUE & WOOD SCREWS AS REQ FOR CAMERA SUPPORT STRUCTURE



bolted on cover permits easy installation and removal of the cameras. Lead containers for the ion chambers are located in two corners of the box. They provide an additional 1-1/2 inch of shielding for the chambers and collimate the beam into the chamber. A double lid is provided for the container to permit lead out of the chamber cable. The camera box with cameras and chambers installed weighs approximately 400 pounds.

j. Portable Vehicle Decontamination Station (Figure IV-18)

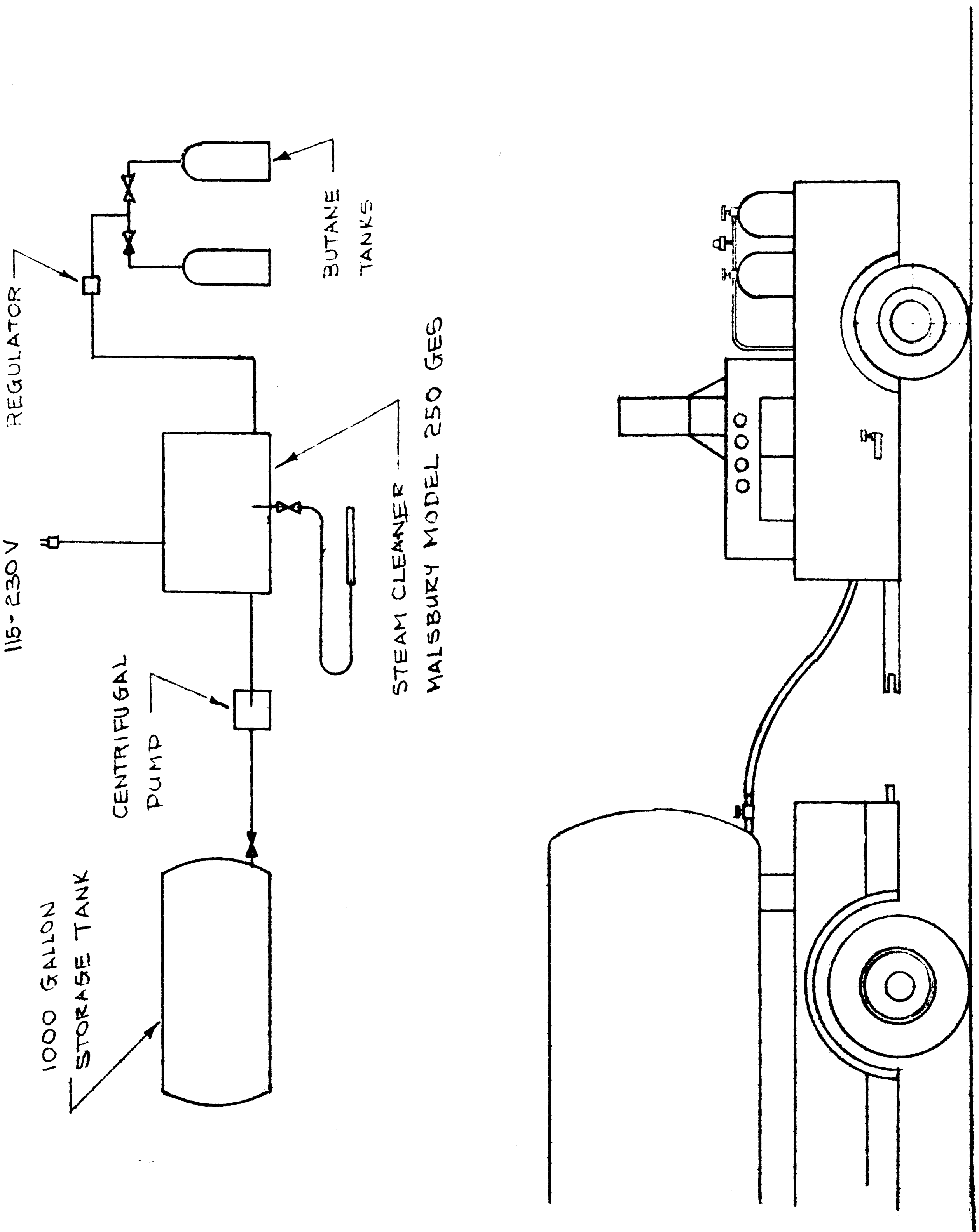
Steam cleaning with detergent solutions would be the primary means of decontaminating. The steam cleaning system and a portable vehicle decontamination pan (Fig. IV-2) would be the primary components of the system.

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

CONTRACT NO. ____________

SUBJECT: PORTABLE STEAM CLEANING SYSTEM

CALCULATION NO. ____________
DWG. NO. SLIRA 1044
SHEET ______ OF ______
DATE 5/11/61 BY EAO
CHECK DATE ______ BY ______



PORTABLE STEAM CLEANING SYSTEM

FIGURE IV-18

3. Typical Specifications for Special Equipment for SL-1 Decontamination and Core Removal

   a. SL1R - Spec. 1 - Specification for Remote Controlled Mechanical Manipulator, February 28, 1961

   b. SL1R - Spec. 2 - Specification for Remote Controlled Closed Circuit Television System, May 5, 1961

   c. SL1R - Spec. 3 - Specification for Reactor Operating Room Ventillating System, May 5, 1961

   d. SL1R - Spec. 4 - Specification for Vacuum Unit for High Level Decontamination, April 25, 1961

   e. SL1R - Spec. 5 - Specification for a Portable Hydraulic Crane, May 11, 1961

SL-1 RECOVERY OPERATION

Specification for Remote Controlled
Mechanical Manipulator

February 28, 1961
SLIR- Spec. I

Prepared by: ______________________
Task Leader

Approved by: ______________________
Project Manager

____
Planning and Design Supervisor

____
Health Physics Supervisor

COMBUSTION ENGINEERING, INC.

NUCLEAR DIVISION

February 28, 1961
SLIR-Spec. 1

SPECIFICATION FOR REMOTE CONTROLLED MECHANICAL MANIPULATOR EQUIPPED WITH A CLOSED CIRCUIT TELEVISION VIEWING SYSTEM

I. SCOPE

The following are requirements for a remote controlled manipulator system which will be mounted on the end of a 50 foot long boom and operated in a high nuclear radiation field. The boom which is mounted on a vehicle will have motion in all directions and will be capable of supporting 1,000 lbs. when fully extended. (See attached sketch)

The manipulator will be used to perform such tasks as moving material out of the high radiation area, engaging an auxiliary hoist to items too heavy for it to lift, operating a commercial vacuum cleaner and an oxy-acetylene torch in the radiation area.

The manipulator will be operated from a console which will be located up to 1,000 feet from the boom truck by observation of television monitors.

II. SYSTEM REQUIREMENTS

A. Operating Conditions for Continuous Operation

1. Temperature - 20 °F to 125 °F.

2. Humidity 0-100% R. H. Atmospheric.

3. Must be dust proof.

4. The TV camera and manipulator must operate in a 1,000 r/hr radiation field for 1,000 hours, minimum.

B. Shock Loading

1. The manipulator and camera will be mounted on the end of a long boom, as shown on enclosed sketch. Therefore they should be able to operate properly when subjected to shock loads up to 5g.

2. The television and manipulator power supplies will be mounted on the boom truck. Shock mountings should not exceed 3 feet x 3 feet x 3 feet.

3. Arm joints should be equipped with slipclutches which will prevent damage to mechanism if it is knocked against immovable objects.

C. Distance Between Components

1. The maximum distance between the TV camera and manipulator and their respective power units is 75 feet.

2. The maximum distance between the power units and the control consoles is 1,000 feet.

3. Heavy duty, easily decontaminated cables should be used between all units. Weatherproof connectors should be used throughout.

D. Size

1. The total weight of the TV camera, manipulator and associated components which mount on the end of the boom should not exceed 400 lbs.

2. The complete assembly which mounts on the end of the boom must be such that it will pass through a 30 inch square vertical opening.

3. The manipulator control, TV control and auxiliary cables and hoses must pass through a 4 inch diameter hole.

E. Decontamination

1. The camera and manipulator will be in a 1,000 r/hr radiation zone and will be in direct contact with highly contaminated matter. The cables and power units will be exposed to radiation of 10 r/hr. For this reason the packaging of these items should be such that they can easily be decontaminated using standard decontamination detergents with a minimum of scrubbing.

2. The manipulator and TV camera positioning device should contain no liquid lubricants or hydraulic fluids.

F. Power Supply

All components should be such that they operate on either 115 volt, single phase or 440 volt, three phase, 60 cycle commercial AC power.

G. Auxiliary Fixtures

1. An oxy-acetylene cutting system modified to be supported in the manipulator hand is to be supplied. The torch is to be capable of cutting through 1 inch thick carbon steel plate and a 12 inch diameter, 1/2 inch wall stainless steel pipe.

2. A remote controlled CO_2 system, capable of 20 lb/min. flow and capable of being mounted adjacent to the torch is to be supplied.

H. Mounting

The manipulator and TV camera assembly should be equipped with a bracket which can be bolted to a plate on the end of a 6 inch wide by 8 inch deep box beam. All the leads will pass through a 4 inch diameter hole in this plate through the beam. The location of the bolt holes in the bracket are optional.

I. Motion

1. Hand must be able to describe a hemisphere of 48 inch radius. Flat side of the hemisphere to be vertical.

2. The hand is to be able to rotate continuously at the wrist.

3. The hand should bend 180° at the wrist about an axis which is perpendicular to the wrist rotation axis.

4. The arm should contain an elbow at the approximate midpoint of the arm. The elbow should bend 180°.

5. The hand should open 3 inches minimum.

J. Manipulator Load Capacity

1. The hand should be able to lift a 50 lb. object from any position and exert a 50 lb. force in any direction.

2. The hand should be able to exert a 30 inch pound rotational torque.

3. The hand should be able to lift 100 lbs. with a straight lift or the arm should be able to take a hook in place of the hand and the hook take a 100 lb. straight lift.

4. The hand should be able to manipulate a large commercial size vacuum cleaner head along a vertical wall and along both floor and the ceiling.

5. The hand should be able to manipulate an oxy-acetylene torch such that it can cut off a 12 inch diameter pipe mounted in either the horizontal or the vertical position.

6. The hand should be able to grasp a 1,000 lb. capacity shackle which is suspended from an auxiliary hoist and shackle it to an object on the floor.

7. The hand should be able to grasp and operate small power tools such as a power hacksaw, 1 inch bolt size impact wrench, etc.

8. Overload clutches should be such that they permit the manipulator arm to slowly drop to the vertical position when over loaded and not let go of whatever is being grasped in the hand.

K. TV Camera Field of Vision

1. The camera must be equipped with a pan and tilt mechanism such that it can observe the manipulator hand in every position.

2. It should be equipped with a zoom type lens or mounted on a movable boom so that it can get a close up picture of the hand in any position.

L. Lighting

1. The camera should be equipped with its own light source.

III. PROOF TESTS

Before a purchase order will be placed the potential vendor will be required to set up the complete system on a mock-up of the crane beam and demonstrate the following:

A. Ability of the system to operate properly after 4 successive impact loads in excess of 5g.

B. Proper control and good TV presentation with the maximum length power and control cables.'

C. Ability of cutting system to be remotely ignited, adjusted and subsequently cut off a section of 12 inch diameter, 1/2 inch wall, stainless steel pipe mounted in a position to be determined at that time.

D. Ability of system to meet all the requirements of sections I and J All above operations are to be conducted by an operator viewing the TV monitor only.

The above tests will be repeated with the final product before delivery is accepted.

IV. SYSTEM COMPONENTS

The vendor is to supply the following components which make up the above system.

A. Mechanical manipulator including necessary power supplies, cable and control console.

B. Oxy-acetylene cutting system including torch, gripping adapters, nozzles, remote igniting system, 75 foot length of hoses and controls which can be adjusted at the end of the hoses.

C. CO_2 extinguisher system including nozzle, mounting bracket, 75' length of hose which will take standard 40 lb. CO_2 bottle.

D. TV system including camera with either a zoom lens or moving arm which will permit it to give close-up presentation of the hand, pan and tilt mechanism, necessary power supplies, cable and monitor.

E. List of recommended spare parts including prices and delivery times.

V. INSTALLATION

The manipulator will be installed on the crane boom by the purchaser. The vendor shall furnish at no extra cost a competent engineer for a period of one to two weeks during installation as a consultant on assembly and operation of the system.

REVISION

SL-I RECOVERY OPERATION

SPECIFICATION FOR REMOTE CONTROLLED CLOSED CIRCUIT TELEVISION SYSTEM

May 5, 1961
SLIR-Spec. 2

Prepared by: W. J. Olsson
W. J. Olsson

Approved by: WKWilhelm
W. K. Wilhelm
Planning & Design Supervisor

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

May 5, 1961
SLIR-Spec. 2

SL-I RECOVERY OPERATION

SPECIFICATION FOR REMOTE CONTROLLED CLOSED CIRCUIT TELEVISION SYSTEM

SCOPE

The following are requirements for a remote controlled closed circuit television system which will be operated in a high nuclear radiation field. The camera will be mounted on a pan and tilt mechanism which will be remotely controlled from the television console 1000 feet from the camera. The system will be used to observe decontamination operations which will be performed remotely

I. SYSTEM COMPONENTS

The vendor is to supply a system consisting of the following components:

A. Television camera with remote controlled variable focus.

B. Pre-amplifier which will be either encased with the camera or 75 feet from the camera.

C. Pan and tilt mechanism which, with a remote control, will support the camera.

D. Amplifier and monitor plus 1000 feet of cable from preamplifier.

E. One standard angle lens and one wide angle lens, non-browning.

II. SYSTEM REQUIREMENTS (See sketch)

A. The television camera, lens, pan and tilt mechanism and any other component mounted with the camera must operate continuously under the following conditions:

1. Temperature -20 °F to + 125 °F

2. Humidity 0 to 100% Relative Humidity

3. Must be dust proof.

4. Must operate in a 1000 r radiation field for at least 1000 hours.

5. Altitude 5,000 feet above sea level.

B. The amplifier, remote controls, monitor and any other units not mounted with the camera must meet requirements No. A 1, 2, and 5.

C. Shock loading; operation of the camera, pan and tilt mechanism and any other components mounted with the camera must not be affected by shock loads up to 15g.

D. Distance between components

1. The minimum distance between the camera and any component not mounted on the camera will be 75 feet.

2. The monitor and remote controls will be located 1000 feet from the camera.

E. Field of Vision

1. The camera will be equipped with a remote controlled focus which will permit focusing from three feet to infinity.

2. The pan and tilt mechanism should provide for 345 $^{\circ}$ pan and 45 $^{\circ}$ tilt above and below the horizontal.

F. Lighting

The camera should be equipped with a lighting system which will provide sufficient light for viewing 40 feet from the camera with no auxiliary light source.

G. Power Supply

All components must operate on 115 volt, single phase, 60 cycle commercial AC power.

H. Size

1. The camera, pan and tilt mechanism and any shielding required for the camera must not weigh more than 75 lbs.

2. The overall size of the camera plus pan and tilt mechanism should not exceed 2 feet x 2 feet x 2 feet.

I. Packaging

1. The camera, pan and tilt mechanism will be in a high radiation zone and will be in direct contact with highly contaminated particles. For this reason the packaging of these items as well as the cable leads should be such that they can be easily decontaminated using standard decontamination detergents with a minimum of scrubbing.

2. All units except the monitor and remote controls should be in weatherproof containers. All electrical connections should be weatherproof.

J. Electronic

1. The camera unit should be a minimum components circuit with ceramic parts.

2. No semi-conductors should be used in the camera or preamplifier.

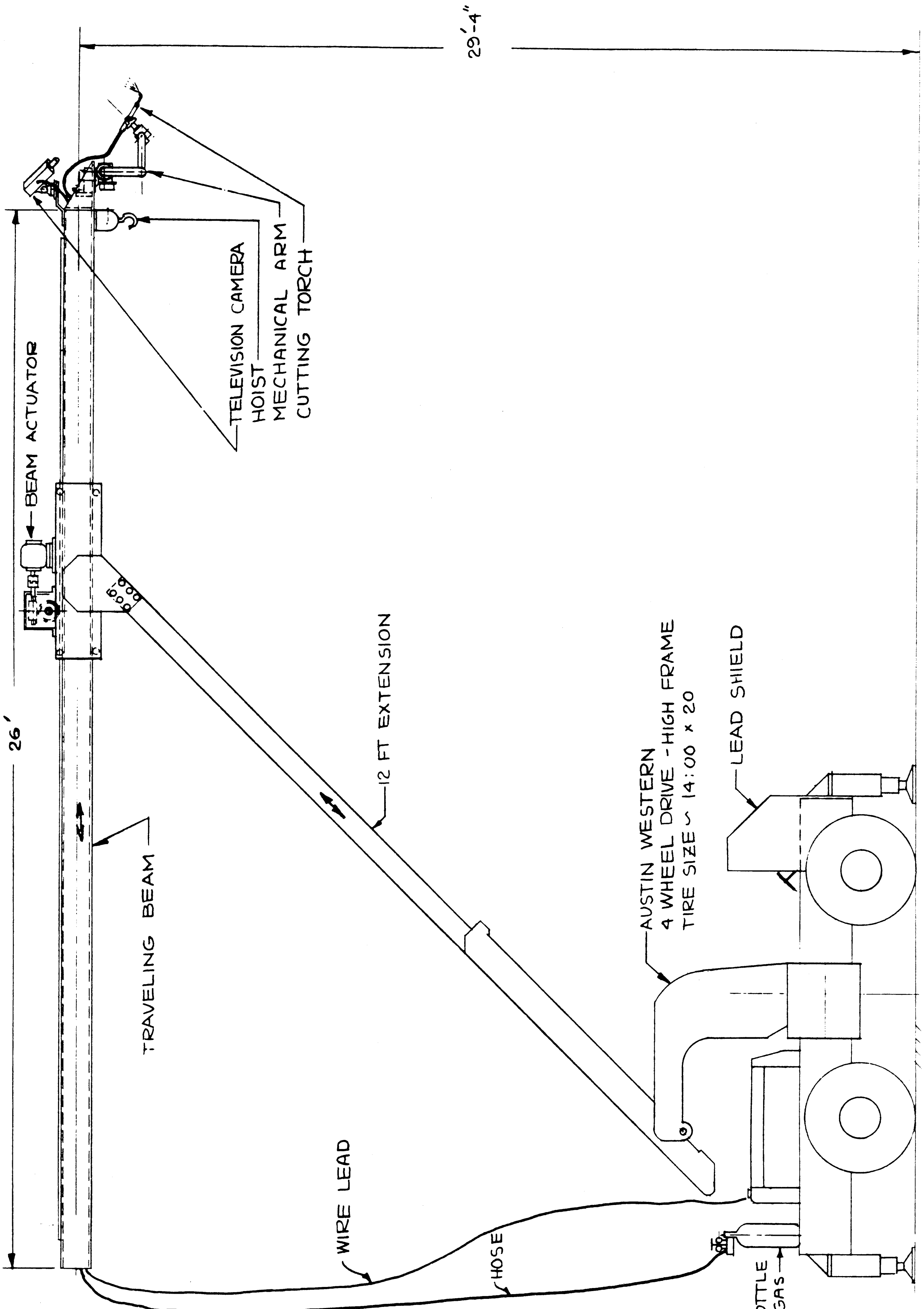
3. Minimum resolution at picture center should be 500 lines horizontal and vertical.

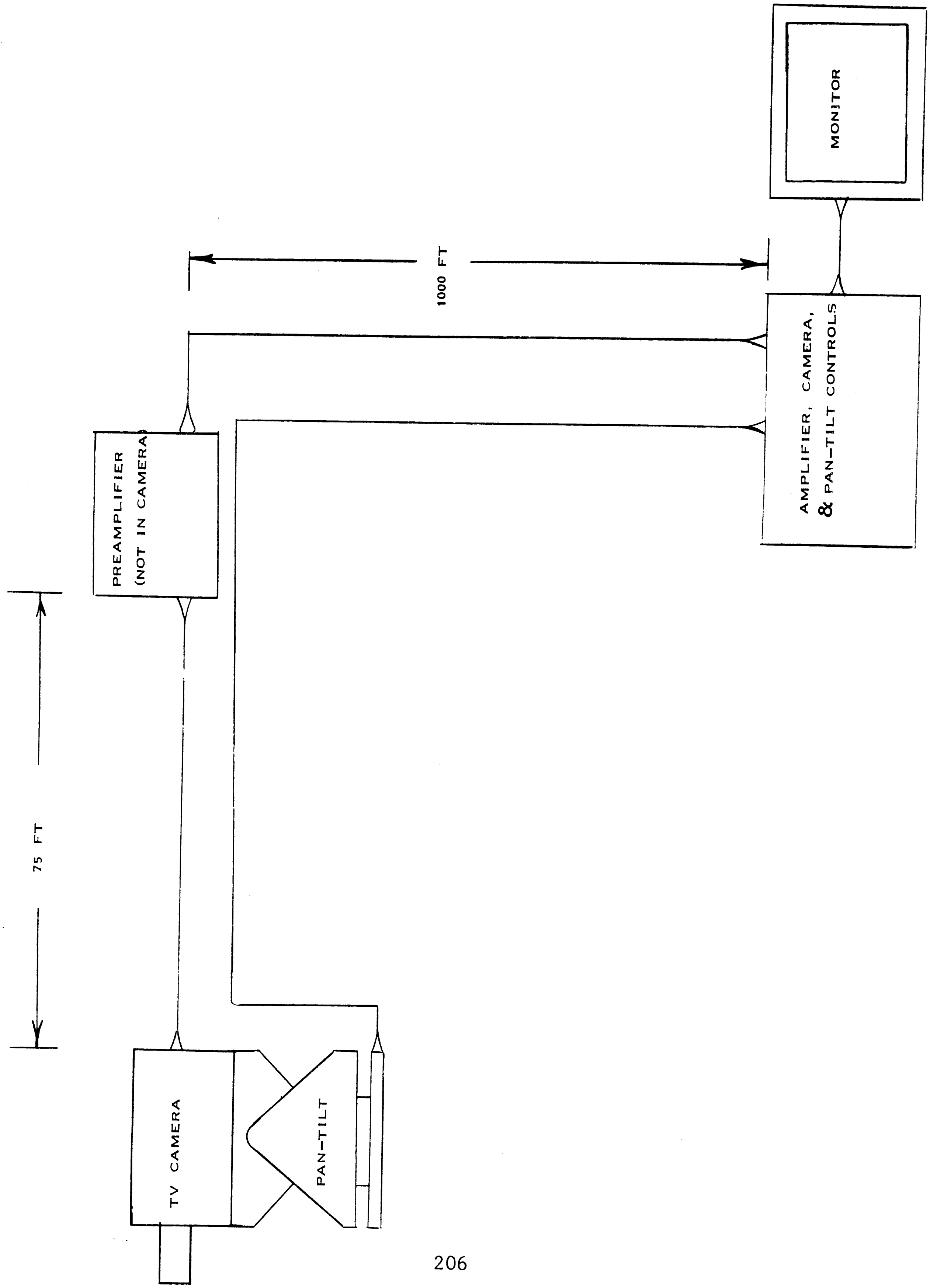
K. Spare Parts

Manufacturer will supply a complete spare parts list with price and delivery time on each item. He should also include a list of recommended spares to be purchased with the system.

L. Shipment

FOB Scoville, Idaho.


29'-4"
TELEVISION CAMERA
HOIST
MECHANICAL ARM
CUTTING TORCH
BEAM ACTUATOR
26'
12 FT EXTENSION
TRAVELING BEAM
AUSTIN WESTERN
4 WHEEL DRIVE - HIGH FRAME
TIRE SIZE ~ 14:00 x 20
LEAD SHIELD
WIRE LEAD
HOSE
BOTTLE
GAS



FIXED TELEVISION CIRCUIT

SL-I RECOVERY OPERATION

SPECIFICATION FOR REACTOR OPERATING ROOM VENTILATING SYSTEM

May 5, 1961
SLIR-Spec. 3

Prepared by: R. H. Young (signed) WJO
R. H. Young

Approved by: W K Wilhelm (signed)
W. K. Wilhelm
Planning & Design Supervisor

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

May 5, 1961
SLIR-Spec. 3

SL-I RECOVERY OPERATION

SPECIFICATION FOR REACTOR OPERATING ROOM VENTILATING SYSTEM

SCOPE

The following are requirements for a ventilating system for a reactor operating room. Due to a reactor accident the reactor operating room is highly radioactive and much of the reactor recovery operation will be performed remotely thru an open freight door in the side of the Reactor Building. See attached Sketch A. The purpose of the ventilating system is to prevent radioactive particles which may be dispersed during the recovery operation from escaping from the building. The ventilating system should not disturb settled particles or remove more material than is necessary to achieve its purpose.

I. DESCRIPTION OF THE BUILDING

The building which contains the reactor is 37 feet in diameter. See attached sketch. The reactor room is 12 feet high and is open to the fan room which is approximately 14 feet tall. The area of the open freight door is 100 square feet. All openings other than normal leakage paths can be closed. The shell of the Reactor Building is 1/4 inch thick steel plate.

II. SYSTEM COMPONENTS

A. The vendor will supply the motor-fan-control unit, and a complete design of the ventilating system in accordance with the following requirements. This includes all the drawings required to build and support the system. The vendor will also completely specify the type and size of the filters in the ventilating system proposal. These filters must meet the requirements of this specification.

B. The buyer will fabricate the entire ventilating system and furnish the filters specified by the vendor.

III. SYSTEM REQUIREMENTS

A. AMBIENT OPERATING CONDITIONS FOR CONTINUOUS OPERATION.

1. Temperature -20 to 125 ^{o}F.

2. Humidity 0 to 100%

3. Must be dustproof

4. Altitude 5000 feet above sea level

B. LOCATION OF THE COMPONENTS. See attached Sketch A.

1. The building will be ventilated thru a hole which will be cut in the side of the Reactor Building near the opposite end of the reactor room from the freight door. The hole centerline will be 27 feet above ground level.

2. The motor-fan unit will be located near ground level and a duct will carry air from the building to the fan.

3. In order to keep contamination of the fan to a minimum the filters must be located before the fan.

4. The ventilation system should be designed with a draft gage capable of reading pressure differentials from 0-5 inches WG across each filter bank.

5. The design should include a lightweight gravity shutter on the discharge side of the fan.

C. FLOW

1. The ventilating system must have a flow damper on the discharge side of the fan capable of reducing flow at least 25% of full capacity.

2. With the damper in the fully open position the minimum capacity of the ventilating system must be 20,000 SCFM.

3. Flow must not be so great that particles which are settled on surfaces in the reactor operating room more than three feet from the duct inlet are removed by the vent system.

4. The system must be designed so that it can be continuously operated at flows ranging from full capacity to 25% of full capacity.

5. Damper position should not change during operation such that flow varies by more than 5% from a preset value.

D. DUCT DESIGN

1. Since the hole in the Reactor Building will be irregularly cut the duct inlet should be provided with a wide flange and gasket arrangement, as shown in Sketch B, so that the duct can be bolted to the Reactor Building.

NOTE: The Reactor Building is a curved surface.

2. Except for transitions, the ducts should be rectangular, or square.

3. The dimensions of the ducts connecting the hole in the Reactor Building to the plenum must not exceed 40 inches x 40 inches.

4. The ducts must be designed with essentially no leakage between the duct inlet and the last bank of filters.

5. All corners and joints preceding the last bank of filters which do not have to be disassembled must be seal soldered or seal welded.

6. At ground level the ducts must be horizontal and at least one foot off the support platform.

7. Each filter bank should be enclosed in a short length of casing such that the casing with the filter bank inside can be removed as a unit. The filter banks will be replaced in this manner.

8. Each filter casing must be easily disconnected and must be removable without disturbing the other filter casing.

9. The filter casings must be designed so that cover plates can be slipped over the open ends when the casing is disconnected.

10. The casing with the filter bank inside must be a self supporting unit and have lifting eyes for crane removal.

11. The duct must exhaust in an upward direction (at least 45 ^{o} above horizontal) and be provided with some arrangement to prevent rain or snow from reaching the fan through the duct.

E. VENTILATING SYSTEM EXTERNAL SUPPORT

1. The area outside the Reactor Building is also in a high radiation field. Therefore the vendor should design a single platform on beams to support the entire ventilating system so that the system can be prefabricated, mounted on the platform,and slid or lifted into place.

2. The ventilating system should be designed so that all external support for the ductwork is supported by the platform.

3. The platform should be provided with a lifting arrangement so that the platform with the ventilating system in place can be lifted with a crane.

F. FILTER DESIGN

1. Two vertical banks of filters are to be installed in series.

2. There must be essentially no leakage past the filters.

3. The ventilation system must be designed such that the filter banks and filter casings are firmly supported at full flow with a six inch WG pressure differential drop across the filters.

4. The first bank of filters should remove most of the particles above one micron diameter.

5. The second bank of filters must be absolute filters.

6. The number of filters must be selected so that flow does not exceed the rated capacity of the filters.

7. The absolute filters must meet the specifications described in Issue No. 120 dated January 20, 1961 from Health & Safety of the United States Atomic Energy Commission, titled "Recommended Manual Specification Revised for the High Efficiency Filter Unit".

8. The filters must meet the requirements of this specification in addition to the AEC specification described in Item No. 7.

9. If special filter separators are necessary because of required operating conditions (0-100% humidity), they must be installed.

10. No air washers, spray-type dehumidifier, or other water contributing devices are to be used in the system.

11. The filters must be readily removable from the bank.

G. MOTOR-FAN-CONTROL UNIT

1. The motor-fan unit must be capable of continuously supplying the required flow specified in paragraph C 2.

2. The motor must be a three phase, induction type motor operable on either 220 volt or 440 volt, 60 cycle, AC power.

3. The motor must be provided with a manual starter and overload protection.

4. The motor must be totally enclosed with a hood cover protecting the motor and drive.

5. The controls must be weather tight and explosion proof.

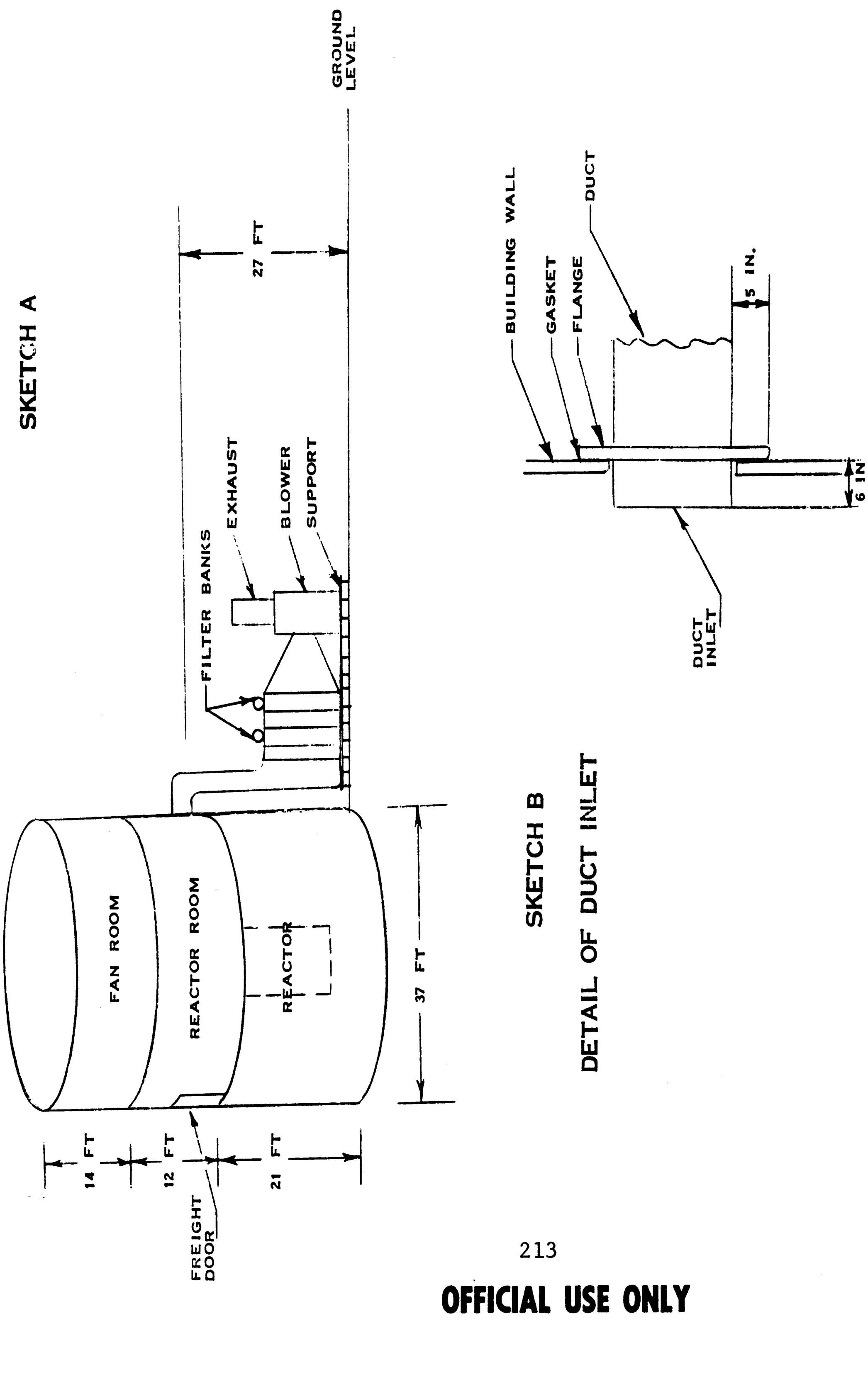
IV. PROOF TEST

A. All absolute filters will be shipped to Hanford, Washington and tested in accordance with Issue No. 105 dated December 22, 1959 from Health & Safety Information of U. S. Atomic Energy Commission titled "Filter Inspection and Testing".

B. The motor-fan-control unit shall be operated continuously for two hours with a simulated load before it is shipped to the buyer.

V. DELIVERY

The vendor will supply the design of the ventilating system, with drawings, within three weeks after the order is placed. The motor-fan-control unit will be supplied within four weeks after the order is placed. Delivery is to be FOB, Scoville, Idaho.



VENTILATING SYSTEM FOR SL-1
FIGURE 1

SL-I RECOVERY OPERATION

SPECIFICATION FOR VACUUM UNIT FOR HIGH LEVEL DECONTAMINATION

April 25, 1961
SLIR-Spec. 4

Prepared by: R H Young
R. J. Young

Approved by: W. K. Wilhelm
W. K. Wilhelm
Planning & Design Supervisor

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

April 25, 1961
SLIR-Spec. 4

SPECIFICATION FOR VACUUM UNIT FOR HIGH LEVEL DECONTAMINATION

SCOPE

The following are requirements for a high powered vacuum unit to be used for removal of dust, debris, radioactive particles, etc. from a Reactor Building. The vacuum unit consists of a portable motor-fan unit, a three stage filtering system, hosing , and attachments (see attached sketch). Filtering will occur on the suction side of the blower in order to keep contamination of the equipment to a minimum. The vacuum unit specified below is similar to the unit used by AECL.

I. MATERIAL TO BE REMOVED

A. Steel cylinders one inch in diameter one inch long.

B. Gravel of all sizes having a maximum size of a one inch sphere.

C. Dust, dirt and powder.

D. Small metal fragments (no larger than Item A).

E. Blotter paper of all sizes having 1-1/2 inch maximum diameter.

II. SYSTEM REQUIREMENTS

A. Operating Conditions

1. Temperature -20 °F to 125 °F

2. Humidity 0 to 100%

B. Hoses

1. A set of hoses will consist of six separate sections (see attached sketch) having lengths as follows:

   a. Three sections approximately 20 feet long (sections can be 16 feet - 24 feet long) totaling 60 feet.
   b. Three short sections having lengths such that the components will be spaced no closer than is shown in the attached sketch.

(1)

2. The hoses must be leak tight.

3. The hoses must be two inches in diameter or larger.

4. The hoses must have sufficient strength to resist excessive wear resulting from removal of the material described in Item No. 1, i.e., the hoses must remain leak tight for a minimum of 200 hours of continuous operation.

5. The pickup hose must not clog, i.e., if the vacuum unit clogs it should occur in the nozzle and not in the hose.

C. Separator and Filters

1. The first filtration stage must be a separator employing centrifugal-gravity action to remove the heavier particles.

2. The separator must be designed so that excessive wear of the separator components does not occur due to the removal of the abrasive material described in Item No. 1. The separator should be designed for a minimum of 200 hours continuous operation.

3. The separator must be designed so that the precipitate is collected in a standard commercial 55 gallon disposable drum.

4. It should not be necessary to remove the drum lid in order to disconnect the drum. If the baffles are part of the drum lid, the lid will be sealed to the drum and the entire unit replaced when necessary.

5. The second filtration stage should be a regular vacuum type filter or group of filters. The dust should be collected in in a bag inside a 55 gallon drum or within the drum itself. It should not be necessary to remove the drum lid in order to disconnect the drum.

6. No particles should pass through the separator which might damage subsequent filters.

7. The third stage of filtration must be an absolute filter or group of filters.

8. The absolute filters must meet the specifications described in Issue No. 120 dated January 20, 1961 from Health and Safety of the United States Atomic Energy Commission, "Reccomended Manual Specification Revised for the High Efficiency Filter Unit".

(2)

9. If special filter separators are necessary in the absolute filter because of the required operating conditions (0-100% humidity) they must be installed.

10. The number of filters must be selected so that flow does not exceed the rated capacity of the filters.

11. The absolute filter or filters should be enclosed in a casing so that the casing with the filters inside can be removed as a unit by disconnecting only the hose connections.

12. The absolute filters should be removable from the casing.

13. All three filter stages should be designed so that they can be replaced by coupling and uncoupling hose connections.

14. There must be no leakage past the absolute filter.

15. Liquid droplets must not reach the absolute filter, i.e., if liquid is picked up by the vacuum unit it must be removed by the separator and vacuum filter.

D. Motor-Blower-Control Unit

1. The motor must be greater than seven horsepower.

2. The motor-blower unit must have sufficient power and suction to remove (with a six foot vertical lift and 60 feet of hose) the material described in Section No. I.

3. The motor-fan unit must be compact, rugged and portable and should be engineered for continuous operation.

4. The motor-fan unit should be guaranteed for one year.

5. The motor must be operable on three phase 220 volt or 400 volt, 60 cycle, AC power.

6. The entire vacuum unit must be operable outdoors.

7. The vacuum unit must be designed so that the motor-blower unit is not damaged if the suction hose becomes plugged.

8. The vacuum unit externals should be easily decontaminated.

E. Attachments

1. The vacuum unit should have the attachments shown on the attached sketch.

2. All couplings and connectors required to use any of the attachments, couple the hose segments, filter, blower unit, etc. should be provided.

3. All couplings, connectors and attachments should be easily connected and disconnected and should be designed with a mechanical locking device so that the hose sections and attachments cannot accidentally uncouple.

III. PROOF TESTS

Before a purchase order will be placed the potential vendor will be required to assemble the complete vacuum unit and demonstrate that the one inch long, one inch diameter steel cylinders can be removed (with six ft. vertical lift and 60 feet of hose).

IV. SYSTEM COMPONENTS

Since it is required by the AEC that all absolute filters used on AEC facilities be tested at Hanford, Washington, the buyer will supply the absolute filter or filters with the capacity specified by the vendor. The buyer will also supply the 55 gallon collector drums.

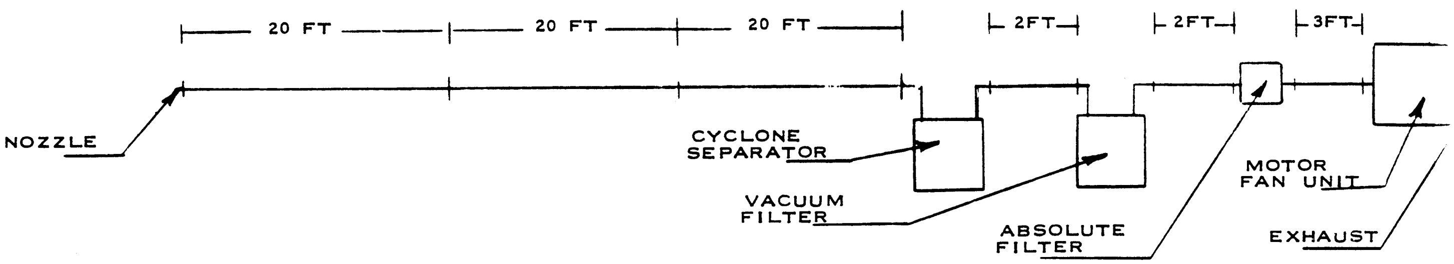
The bid by a potential vendor should be based on one complete vacuum unit plus one complete set of spare hoses and attachments plus two additional spare 20 foot hose sections. In addition the potential vendor should specify the size and capacity of the absolute filter in the vacuum unit proposal. A spare parts and attachments price list should be included.

The vendor should also recommend any additional spare parts which the buyer might require in order to prevent delay in operation.

V. DELIVERY

The vendor must supply the complete vacuum unit within four weeks after the order is placed.

VACUUM UNIT SCHEMATIC

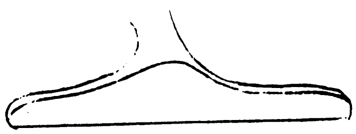


SET OF ATTACHMENTS

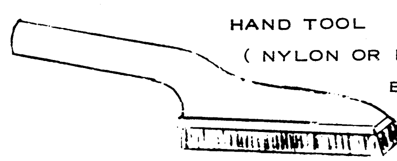
(COUPLINGS REQUIRED TO USE ANY OF THE TOOLS BELOW SHOULD BE INCLUDED. ATTACHMENTS SHOULD BE APPROXIMATELY STANDARD SIZE FOR THE HOSE SIZE SPECIFIED BY THE VENDOR)

CREVICE TOOL

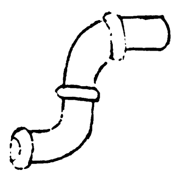
HAND BRUSH (STEEL BRISTLES)



CARPET TOOL

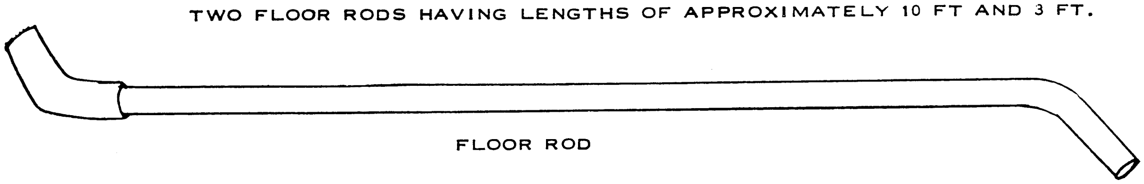


HAND TOOL (NYLON OR FIBER BRISTLES)



SWIVEL

TWO FLOOR RODS HAVING LENGTHS OF APPROXIMATELY 10 FT AND 3 FT.



FLOOR ROD

SL-I RECOVERY OPERATION

SPECIFICATION FOR A PORTABLE HYDRAULIC CRANE

May 11, 1961
SLIR-Spec. 5

Prepared by: W. J. Olsson
W. J. Olsson

Approved by: W K Wilhelm
W. K. Wilhelm
Planning & Design Supervisor

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

SLIR-Spec. 5
May 11, 1961

SPECIFICATION FOR A PORTABLE HYDRAULIC CRANE

SCOPE

The following are the requirements for a portable hydraulic crane to be used for the SL-1 Reactor decontamination and core removal. The crane will be used to move objects in the SL-1 area, remove objects from the Reactor Building and support a 1000 lb. capacity traveling beam. The traveling beam will be used to reach into the Reactor Building and support or lift various pieces of equipment.

I. COMPONENTS TO BE SUPPLIED

A. The vendor is to supply the following:

1. One hydraulic crane per the below listed specifications.

2. One set of interchangable telescoping boom sections to meet the requirements for reach.

3. List of recommended spare parts.

II. CRANE SPECIFICATIONS

A. Capacity

	Height of hook above ground	Horizontal distance from hook to front bumper	Hook Capacity
1.	27 feet	5 feet	15,000 lb.
2.	27 feet	15 feet	4,000 lb.
3.	27 feet	20 feet	2,500 lb.
4.	40 feet	12 feet	4,000 lb.

B. Boom Motion

1. Maximum height of hook above ground - 40 feet

2. Boom telescoping distance, under load - 8 feet

3. Boom horizontal swing - 140° arc

4. Boom vertical arc - sufficient to meet above reach requirements.

C. Hoist

1. Cable hoist rate under load - 20 feet per minute maximum.

2. Hoist distance - crane must be able to lift weights noted in paragraph II - A to heights noted with a straight lift either by cable lift alone or with a combination of cable lift and boom motion.

D. Truck

1. Road speed - 0 to 15 MPH.

2. Tires - pneumatic, 12 ply minimum.

3. Ground clearance - 10 inch minimum.

4. Power - gasoline or diesel.

5. Turn radius - 21 feet.

6. Truck should be capable of supporting a one inch thick lead shield on top of the crane cab.

7. The truck should be able to climb a 10% grade with a 15,000 lb. load.

E. Traveling Beam

1. The telescoping boom should be such that the hook can be removed and replaced with the 1,000 lb. capacity, horizontal traveling beam as shown in Figures I & II. (Customer supplied)

2. The boom must be able to support the traveling beam, horizontally 28 feet and 38 feet above the ground. The boom should be able to telescope four feet in and four feet out from both these positions.

3. The boom when telescoped out to the full height must be able to support the traveling beam in the fully extended position with a 1000 lb. load at the end of the beam. The boom, must be able to swing from this position.

4. The crane must be able to move and swing the boom with the boom telescoped out to the full height, the traveling beam in the retracted position and a 1000 lb. weight at the end of the beam.

F. Radiation

1. All components of the crane including hoses, lubricants and hydraulic fluids must be such that they can operate in a 100 r nuclear radiation field for an unlimited time with no decomposition due to the radiation.

2. The crane will be in direct contact with highly contaminated matter therefore the design should be such that it can be easily decontaminated using standard methods of decontamination.

G. Operating Conditions

1. Temperature -20° F to 125° F.

2. Humidity 0 to 100% R. H. Atmospheric.

3. Must not be affected by dust storms.

4. 5,000 feet altitude.

H. Shipment

Crane will be shipped FOB, NRTS Idaho

V REFERENCES

1. IDO-19003 - SL-1 Reactor Evaluation Final Report, July 15, 1959

2. ANL-5744 - Hazards Summary Report on the ALPR, November, 1958

3. ANL-6084 - Initial Testing and Operation of ALPR, December, 1959

4. IDO-19016 - Plant Expansion Hazards Evaluation, June, 1960

5. IDO-19300 - SL-1 Reactor Accident, Interim Report, May 15, 1961

6. AEC-IDO - Information for Press and Radio Release No. 61-11, January 12, 1961, 12:30 P.M.

7. DR-RO-15 - Summary of Radiation in SL-1 Reactor Building, April, 1961

8. N-PZ-11 - Detailed P.I. Study of the SL-1 Reactor Core and Vessel Damage ; U. S. Naval Photographic interpretation Center, April, 1961

9. Plan for the Reactivity Reduction and Shielding of SL-1 by the Addition of a Poison Solution; Combustion Engineering, Inc., Nuclear Division, Windsor, Connecticut

10. Decontamination, Core Removal, and Inspection Plan for the SL-1 Reactor; Combustion Engineering, Inc., Nuclear Division, Windsor, Connecticut

A P P E N D I X

VI APPENDIX

STUDY OF A TYPICAL OPERATIONAL ENTRY INTO SL-1

The Weekly Summary Report of SL-1 Recovery Operation dated April 19, 1961 contained the following terse statement: "After mock-up work at Central Facilities, an entry was made into the reactor operating floor on April 15, 1961, in accordance with Procedure EP-RO-16, Procedure for Surveying Water Level in SL-1 Reactor Using Miniature Camera. The chemical probe was dropped as indicated, 16 feet 3 inches below No. 8 flange with no evidence of water. Minox camera pictures showed that the probe had been dropped through No. 8 shroud."

The complete planning, execution, and reporting of this entry are documented in the list below and included in this appendix.

1. Procedure for Surveying Water Level in SL-1 Reactor Vessel Using Miniature Camera (Revision No. 1) dated April 15, 1961.

2. SL-1 Control Point Log dated April 15, 1961.

3. Entry Report No. 16 (Internal).

4. Summary of Results from Entry EP-RO-16, Revision No. 1, dated April 17, 1961.

5. SL-1 Health Physics Data Report No. X dated April 20, 1961.

COMBUSTION ENGINEERING, INC.

NUCLEAR DIVISION

PO BOX 2558 • IDAHO FALLS, IDAHO

April 15, 1961
OP-RO-3126

Dr. C. Wayne Bills, Technical Director
SL-1 Recovery Operations
Idaho Operations Office
U. S. Atomic Energy Commission
Post Office Box 2108
Idaho Falls, Idaho

Subject: Request for Approval of Revised Entry Procedure EP-RO-16
Contract AT(10-1)-967

Dear Dr. Bills:

Enclosed are forty-five copies of Procedure EP-RO-16, Revision No. 1, Subject: Procedure for Surveying Water Level in SL-1 Reactor Using Miniature Camera.

Your review, approval, and return of one executed copy are requested.

Very truly yours,

COMBUSTION ENGINEERING, INC.

W. B. Allred
ABWR Project Manager

Enclosures - 45

cc: G. E. DeVore

WBA:a

April 15, 1961

PROCEDURE FOR SURVEYING WATER LEVEL IN SL-I REACTOR VESSEL USING MINIATURE CAMERA

(REVISION NO. I)

APPROVED:

COMBUSTION ENGINEERING, INC.
NUCLEAR DIVISION

[signature]
Operations

[signature]
Design

[signature]
Health Physics

[signature]
Project Manager

U. S. ATOMIC ENERGY COMMISSION

EP-RO-16
Revision No. 1
April 15, 1961

PROCEDURE FOR SURVEYING WATER LEVEL IN SL-I REACTOR VESSEL USING MINIATURE CAMERA

A. OBJECTIVE

1. To obtain liquid level and verify temperature in the SL-1 reactor vessel.

2. To verify the location of the water level detector within the reactor core.

3. To obtain additional photographs of the reactor vessel interior.

4. To obtain additional radiation measurements.

B. EQUIPMENT

1. Test Equipment

   a. Chemical water level probe with temperature sensitive elements.

   b. Miniature camera probe.

   c. Remote camera control unit.

   d. Film Badges and dosimeters.

   e. Carrying container for water level probe.

   f. Spring scale.

2. Support Equipment

   a. Michigan crane with attached closure for Reactor Building door.

   b. Shielded Austin-Western hydraulic crane.

   c. Horizontal sliding beam attached to the Austin-Western crane.

   d. Spotting tower outside fence perimeter, binoculars, and spotting scope.

e. Extension cord for 110 volt AC power from head bolt heater rack.

f. Pump house personnel shield.

f. Canvas on ground beneath freight door.

C. PERSONNEL

Door Opening and Closing		Calculated Dose - mr
1. Michigan Crane Operator	(HKF)	140
2. Michigan Crane Oiler	(HKF)	140
3. Michigan Crane Tagline	(HKF)	140
4. Health Physics Monitor	(CE)	70
Operations		
1. Austin-Western Crane Operator	(HKF)	200
2. Austin-Western Crane Signalman	(HKF)	295
3. Tower Spotter	(HKF)	100
4. Tower Signalman	(HKF)	100
5. Probe Operator	(Cadre)	325
6. Operation Supervisor	(CE)	200
7. Instrument Monitor	(CE)	50
8. Health Physics Monitor	(CE)	150
9. Probe Recovery	(CE)	300
10. AEC Observer	(AEC)	100
11. CE Observer	(CE)	100
12. Electrician	(HKF)	125
13. Operation Photographer	(PP Co)	50
14. Health Physics Monitor	(PP Co)	50

D. OPERATION PREREQUISITES

1. Mock-up testing of procedure completed.

2. Training of all personnel completed.

3. All equipment installed and tested at Control Point.

E. PREPARATORY STEPS

1. Equipment to be used will be assembled and installed at the SL-1 Control Point. The water level probe and camera will be attached to the crane boom and tested for operation.

2. Film badges and dosimeters will be attached to the probes and boom in accordance with Section G.

3. All personnel involved in the operation will attend an Operations and Health Physics briefing. The following subjects will be discussed and any questions answered.

   a. Radiation levels expected.

   b. Alarm system and evacuation routes.

   c. Supervisory control of entry.

   d. Vehicle assignments for transportation to and from the site.

4. All personnel involved in the operation will be dressed in protective clothing under Health Physics supervision, and issued dosimeters and film badges.

F. STEP BY STEP PROCEDURE

1. The Michigan crane operator, oiler, tagline operator and Health Physics monitor will enter SL-1 site, open freight door closure, and return to the Control Point.

2. Crane will proceed to site and stop on pavement by corner of site access fence. Canvas covers will be placed on crane tires.

3. When covers are on crane tires, all operations personnel will drive to site and park vehicles in designated parking area on Fillmore Blvd. All vehicles will remain on pavement.

4. Health Physics monitor and Instrument observer will check-out area for abnormal conditions.

5. Crane will enter site and stop at Administration Building, where electrician will ready camera and attach the chemical probe to the crane boom.

6. Crane will level boom then proceed behind Reactor Building. (Probe operator will ride on crane holding cables.)

7. Supervisor, electrician, and Health Physicist will go behind pump house shield while crane is moving into position. Electrician will check power cord.

8. Crane will be positioned under freight doors passing close to pump house.

9. Check tower for level of boom even with top of shield blocks. Raise by telescoping boom.

10. Electrician connect power cord and ground lead to crane. Check power indicator light on camera control box.

11. Drive crane in to plumb bob and align with outriggers.

12. Crank boom in 20 feet one inch.

13. Boom right 10 inches.

14. Lower chemical probe approximately two feet and check tower for alignment over hole No. 8 using rack in No. 1 for reference.

15. Lower probe until it hits head. Mark string with paint.

16. Raise probe.

17. Crank boom in one inch (20 feet two inches.)

18. Lower probe into hole No. 8.

19. Repeat steps 19 and 20 until probe drops into hole No. 8.

20. Lower probe, marking string every three feet until it hits core. (14 feet minimum distance). Check string tension with spring scale.

21. Probe for hole in core, moving boom in or out if necessary. <u>12 minutes</u> allowed to find hole; 15 feet six inches minimum depth. (Check string tension with spring scale.)

22. If probe penetrates to minimum depth, proceed with <u>Step 26.</u>

23. If probe does not find minimum depth in alloted time, raise probe, boom left 12 inches, and drop probe into hole No. 7. Six minutes allowed to drop probe for minimum depth. No pictures will be taken of water probe in No. 7.

24. Leave probe in place under No. 8 hole for six minutes.

25. Drop camera into hole No. 8 to cable stop (front of camera probe 30 inch below flange) after cranking boom forward two inches.

26. Take pictures using 1, 2, 3, 4, 5, and 8 second exposures.

27. Raise the water level probe in five inch increments, repeating Step 28 at each increment. (Raise camera slightly if probe cable binds on camera cable stop.) A total of 42 pictures will be taken.

28. When 42 pictures have been taken, raise camera to boom.

29. Raise water level probe to boom.

30. Crank boom out to Eight feet. CHECK RADIATION LEVEL UNDER DOOR FOR INCREASE.

31. Crank boom all the way out. Disconnect power.

32. Raise outriggers and back crane so probe can be lowered to canvas on ground under door.

33. Tower personnel will leave position on tower and drive to Control Point.

34. Drop water level probe to canvas. Monitor probe for excessive contamination. (If probe is too "Hot" to handle it will be left lying on canvas until a suitable shield is obtained.)

35. Cut probe string at Operator's platform. Place probe in container and examine.

36. When probe has been removed, drive crane to Decontamination Point.

37. Place probe in plastic bags and take to Control Point.

38. All personnel will evacuate in vehicles that they came in. Grey sedan will leave the area last.

39. When Operations personnel have left area, crew will return to site and close freight door.

40. Film magazine will be taken from camera at Decontamination Point by CEI Observer and Supervisor.

G. DOSIMETER REQUIREMENTS

1. Eight No. 558 gamma film packs will be placed on the Austin-Western crane carriage frame.

2. Four No. 558 gamma film packs will be mounted on the movable boom and bracket.

3. Adlux #1290 films (range 3 to 750 r) wrapped in aluminum foil will be taped on the movable boom at three inch intervals for a distance of three feet starting at the front end of the boom. From the three foot point, films will be placed at two foot intervals along the remaining length of the boom.

4. Two #1290 films in aluminum foil will be on the cable at the top of the camera case.

5. The following items during the operation will be recorded:

   a. Time required for positioning camera in doorway.

   b. Time boom in Reactor Building. (Cranking in to cranking out).

   c. Time boom is over reactor vessel head and height above head.

   d. Time camera is in vessel.

   e. Time camera removed from vessel.

SL-1 CONTROL POINT LOG

COMBUSTION ENGINEERING, INC. DAILY ACCESS TABULATION DATE 15 April 1961

NAME	COMPANY	AREA ENTERED	HP MONITOR	TIME IN	TIME OUT	DOSIMETER READING, MR	DOSIMETER NUMBER	REMARKS AND REASON FOR ENTRY
								Accomplish Procedure EP-RO-16, Rev. 1
Judkins, M.	HKF	SL-1 Site	Davis	0920	0940	46	2436	Open Freight Doors - Crane Operator
Jackovac, C.	HKF	Ditto	Davis	0920	0940	35	2388	Ditto Crane Operator
Davis, S. C.	Cadre	SL-1 Site	HP	0920	0940	78	2438	Ditto - HP Monitor
Eitson, W. A.	HKF	Ditto	Witik	1126	1320	30	2632	Crane Operator
Tripp, H. V.	HKF	Ditto	Witik	1126	1320	125	2388	AW Crane Signalman & Boom Operator
Clark, F.	HKF	Ditto	Witik	1145	1237	45	2711	Tower Spotter
Dyer, W.	HKF	Ditto	Witik	1145	1237	73	0324	Tower Signalman
Kappel, H.	Cadre	Ditto	Witik	1145	1300	165	2438	Probe Operator
Etz, W. H.	CEI	Ditto	Witik	1145	1247	80	2436	Supervisor
Luke, C. W.	CEI	Ditto	Witik	1145	1314	10	0325	Instrument Monitor
Witik, J.	CEI	Ditto	HP	1145	1305	58	0309	HP Monitor
Damour, P. R.	CEI	Ditto	Witik	1145	1247	50	2427	Probe Recovery
DeVore, G. E.	MRD	Ditto	Witik	1145	1247	50	2442	Official Observer
Notari, G.	CEI	Ditto	Witik	1145	1300	50	2384	Observer
Rapp, M.	HKF	Ditto	Witik	1145	1320	76	0345	Electrician
Holmes, R.	PP Co.	Ditto	Christiansen	1145	1237	22	0332	Photographer
Christiansen	PP Co.	Ditto	HP	1145	1237	20	2431	HP for PP Co. Personnel
Davis, S. C.	Cadre	Ditto	HP	1258	1324	520 (Off Scale)	2737	Close Frt. Doors (Discovered Hot Area under freight doors)
Judkins, M.	HKF	Ditto	Davis	1258	1324	67	2442	Michigan Crane Operator
Jakovac, C.	HKF	Ditto	Davis	1258	1324	93	2431	Ditto
Stolla, G. J.	Cadre	Fillmore Blvd.- in Front of SL-1 Site	HP	1137	1247	10	2429	Cover Austin Western Tires to prevent contamination of Road
Layfield, R.	CEI	Ditto	HP	1137	1320	11	0719	Ditto
Davis, S. C.	Cadre	Ditto	HP	1137	1237	10	2737	Ditto

April 15, 1961

ENTRY REPORT NO. 16

I INTRODUCTION

This entry was performed following procedure EP-RO-16, Revision No. 1, at the SL-1 Site on April 15, 1961 to:

1. Place a water level and temperature sensing probe into the SL-1 reactor core.

2. Verify the location of the probe with photographs taken by a miniature camera.

3. Obtain radiation level information inside the reactor building.

The water level probe was lowered into the reactor to a maximum depth of 16 feet 3 inches in the No. 8 control rod channel. Forty-two photographs were taken showing the probe in the control rod channel.

The water level probe did not indicate the presence of water at the maximum depth. The indicator springs in the temperature sensing elements were not expanded.

Radiation level information is reported in Summary of Results, EP-RO-16, April 16, 1961.

II REPORT OF EVENTS

1. All equipment and personnel were assembled at the SL-1 Control Point.

2. A three man crew entered the SL-1 site, opened the Reactor Building freight doors with a Michigan Crane, and returned to the Control Point.

3. The camera was loaded and installed in its shielded case, then tested for proper operation. The check list (Addendum A) was reviewed to insure that all equipment was on hand. The water level probe line was repainted with reflecting paint.

4. All personnel were dressed in protective clothing under Health Physics supervision and issued personal dosimeters and film badges.

5. All personnel were briefed on the operation procedure and assigned vehicles for transportation to the site. The Health Physics Supervisor explained the alarm system and emergency evacuation routes.

6. The crane was driven to the site and parked at the corner of the perimeter fence (Figure VI-1). Control Point personnel installed canvas covers on the crane tires.

7. When the tires had been covered, the crane entered the site and stopped in front of the Administration Building. Operations personnel parked their vehicles in the designated parking area and entered the site.

8. The Health Physics and Instrument Monitors checked the site for unusual conditions, and found radiation levels normal.

9. The crane operators readied the camera and attached the water level probe on the crane boom. The boom was then raised and leveled by the probe operator.

10. The crane was driven into position under the open freight door (Figure VI-2). The electrician and supervisor placed a canvas tarp on the ground under the freight door. The electrician connected power to the crane and checked the camera control box for AC power.

11. The spotters climbed to position on the Observation Tower.

12. The crane was aligned with the monorail beam, and the telescoping boom lowered to obtain proper height above the shield blocks.

13. The horizontal beam was run into the Reactor Building a distance of 19 feet 6 inches, and traversed 10 inches to the right.

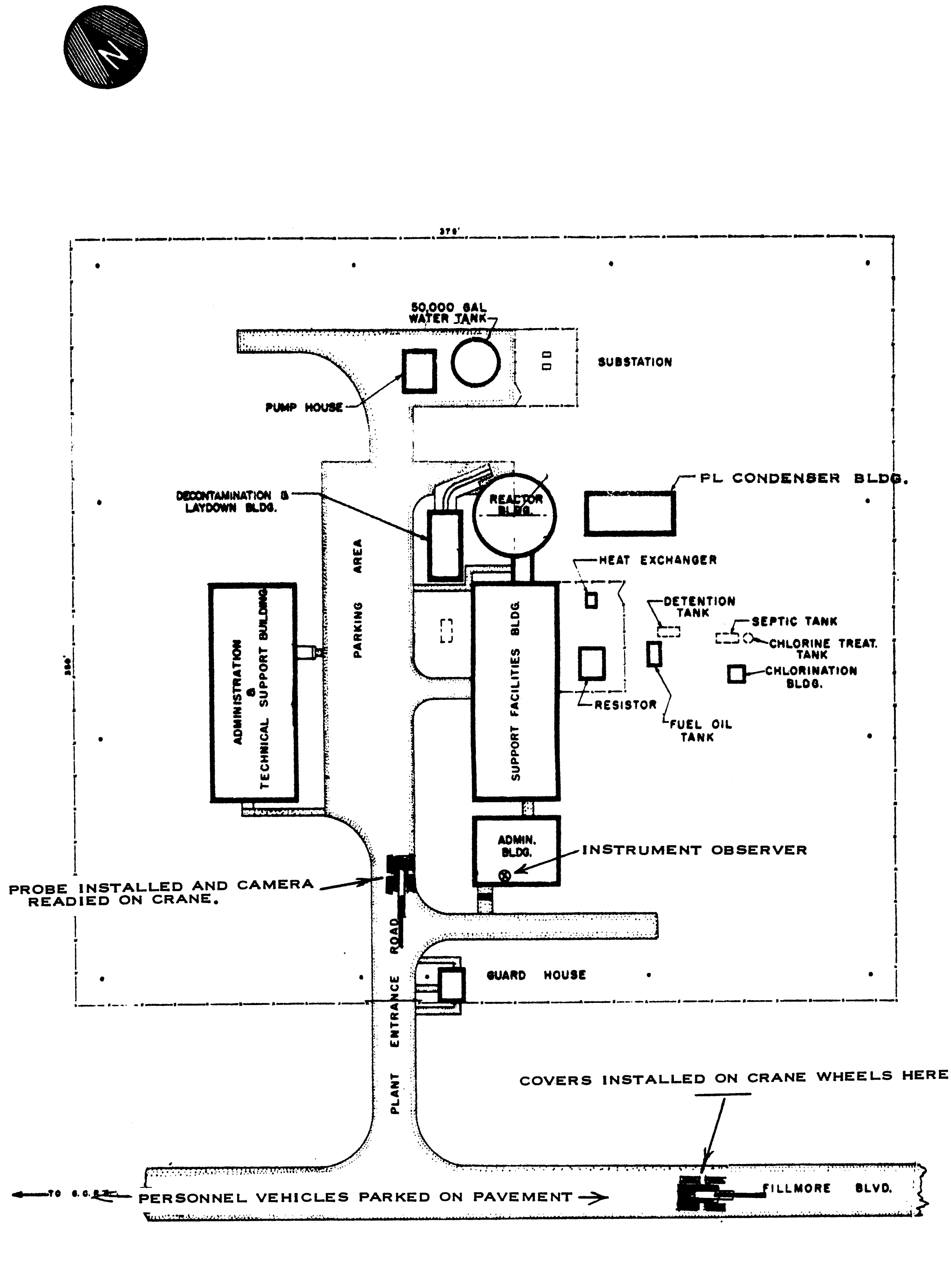
14. The water level probe was dropped until it touched the reactor head to determine a zero point and the probe line marked with paint.

15. The beam was moved in to 20 feet and the probe dropped again to the flange. The beam was traversed two inches to the right, and the probe dropped into the No. 8 nozzle opening.

16. The probe was dropped to bottom at approximately 12 feet and checked with the spring scale. The probe string was marked with paint every three feet as it was dropped.

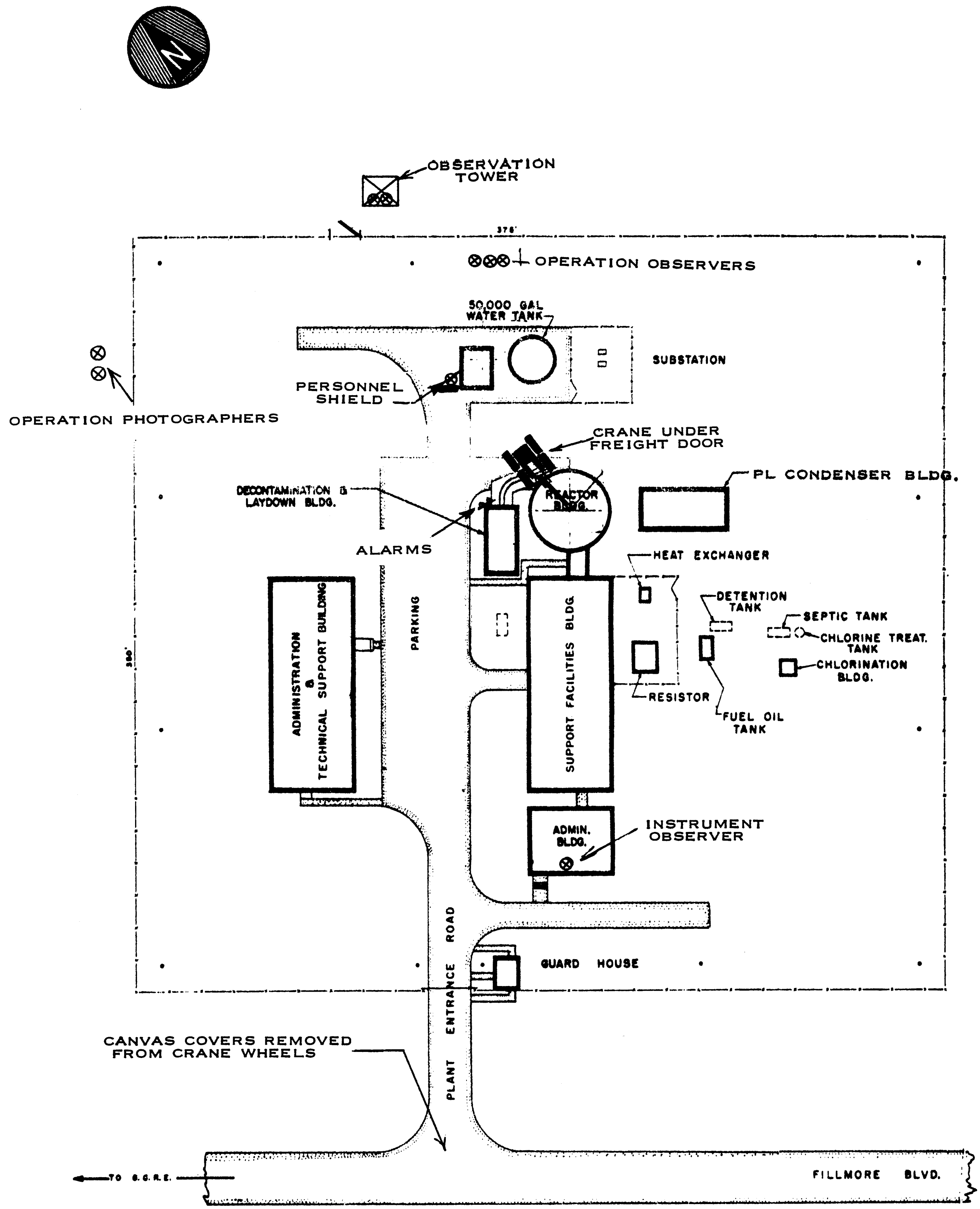
17. The probe was moved up and down several times and dropped freely to 16 feet 3 inches. The probe was again weighed with the spring scale.

18. The probe was left in this position for six minutes for the water detectors to operate.



PERSONNEL AND EQUIPMENT LOCATION PRIOR TO ENTRY

FIGURE VI-1



PERSONNEL AND EQUIPMENT LOCATION DURING ENTRY

FIGURE VI-2

19. The camera was dropped into the No. 8 nozzle to cable stop.

20. A series of six pictures were taken (1, 2, 3, 4, 5, and 8 second exposures) with the water level probe at maximum depth.

21. The water level probe was raised in five inch increments with the series of pictures taken at each step. A total of 42 pictures were taken as the probe was raised.

22. When the pictures were taken, the camera and the water level probe were raised to the horizontal beam.

23. The horizontal beam was withdrawn from the Reactor Building. No radiation increase was noticed as the beam was being withdrawn.

24. The crane was backed up, and the water level probe lowered into its carrying container. No excessive radiation was noted on the probe.

25. The water level probe line was cut at the probe and at the operator's platform.

26. The crane was driven to the front of the Administration Building and the camera lowered for carrying. The tower spotters climbed down and went around the site to the parking area.

27. The crane was driven to the Decontamination Point, stopping at the gate to have the wheel covers removed.

28. All personnel returned to the Control or Decontamination Points.

29. The camera was removed from its case at the Decontamination Point and the film taken to Central Facilities for processing.

30. A three man crew returned to the site and closed the Reactor Building freight doors.

III REMARKS

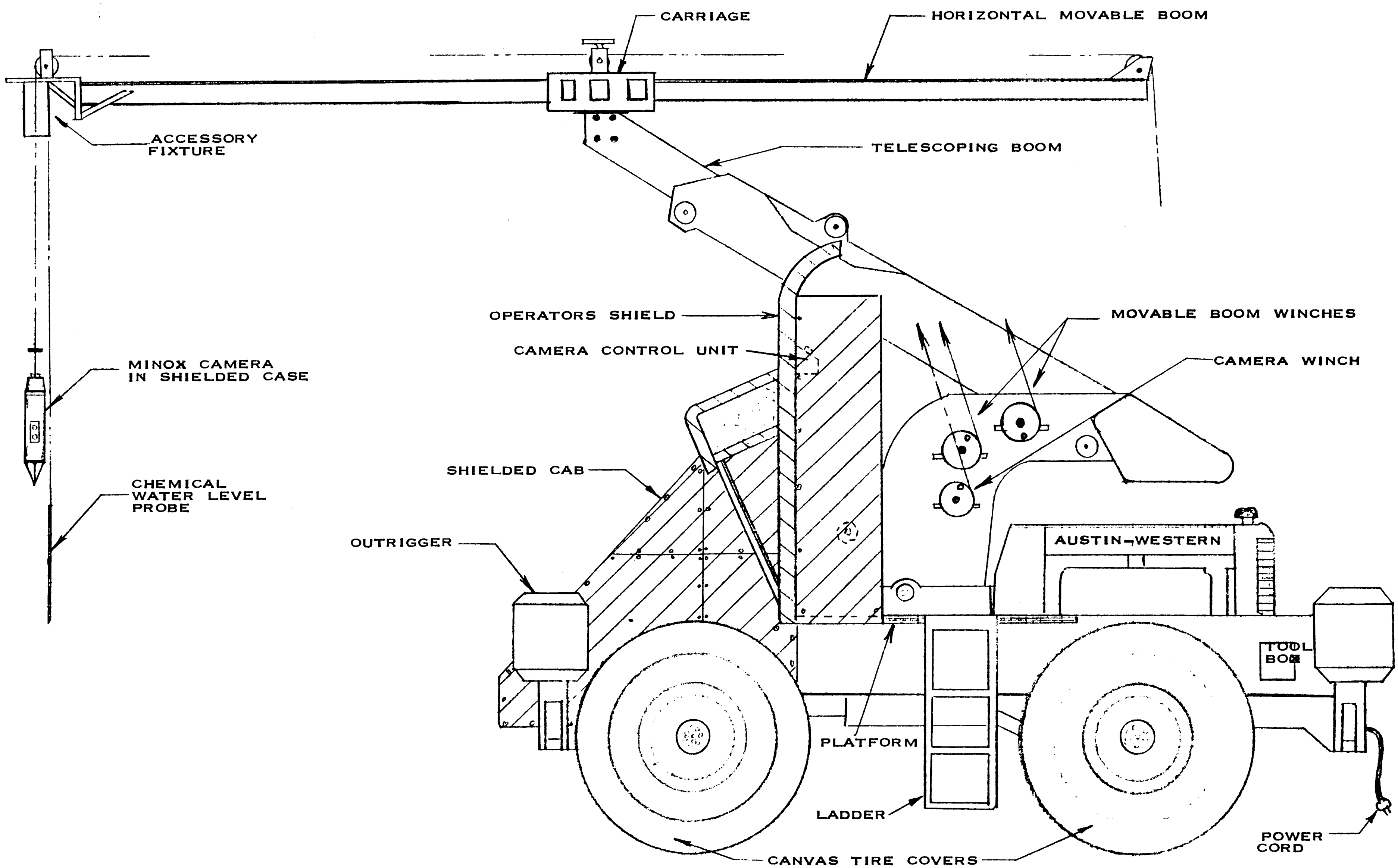
No difficulties were encountered during this operation, and all equipment and personnel performed satisfactorily.

IV DESCRIPTION OF EQUIPMENT

A. CRANE

The Austin-Western shielded crane (Figure VI-3), was used to remotely place the water level probe and the camera into the reactor vessel.

The horizontal movable beam was modified to carry the camera power cable with heavy duty pulleys.



AUSTIN-WESTERN CRANE RIGGED FOR WATER LEVEL PROBE & MINIATURE CAMERA

FIGURE VI-3

A third winch was added to the operator's platform to carry the camera cable.

Canvas covers were taped over the crane tires to prevent contamination of the tires while the crane was inside the site. Upon leaving the site, these covers were removed before the crane was driven on the Fillmore Blvd. pavement.

B. CAMERA ASSEMBLY

A standard "Minox" camera (Figure VI-4), was adapted for use in a high radiation field and for remote operation. The camera is mounted in a stainless steel case with a minimum of 0.75-inch of lead shielding. The camera assembly is shown in Figures VI-5 and VI-6.

The camera shutter is cocked and the film advanced by a solenoid mounted above the camera. The shutter is opened and closed by a second solenoid mounted off to the side of the camera.

The camera is mounted facing a 45^{o} front silvered mirror so that the camera does not directly face the radioactive objects being photographed.

The Minox Camera uses 9 millimeter film in a 50 exposure cartridge. A fine grain, documentary film was used which has a high radiation resistance.

The camera shutter was set for time exposures due to the slow film speed and low lighting level. Bracketed exposures at 3, 4, 5, 6, and 8 seconds were used. A block was clamped to the camera assembly cable which rests on the nozzle flange when the camera assembly is lowered into the reactor and prevents any camera movement during the time exposures. The camera operator times the exposures with a stopwatch.

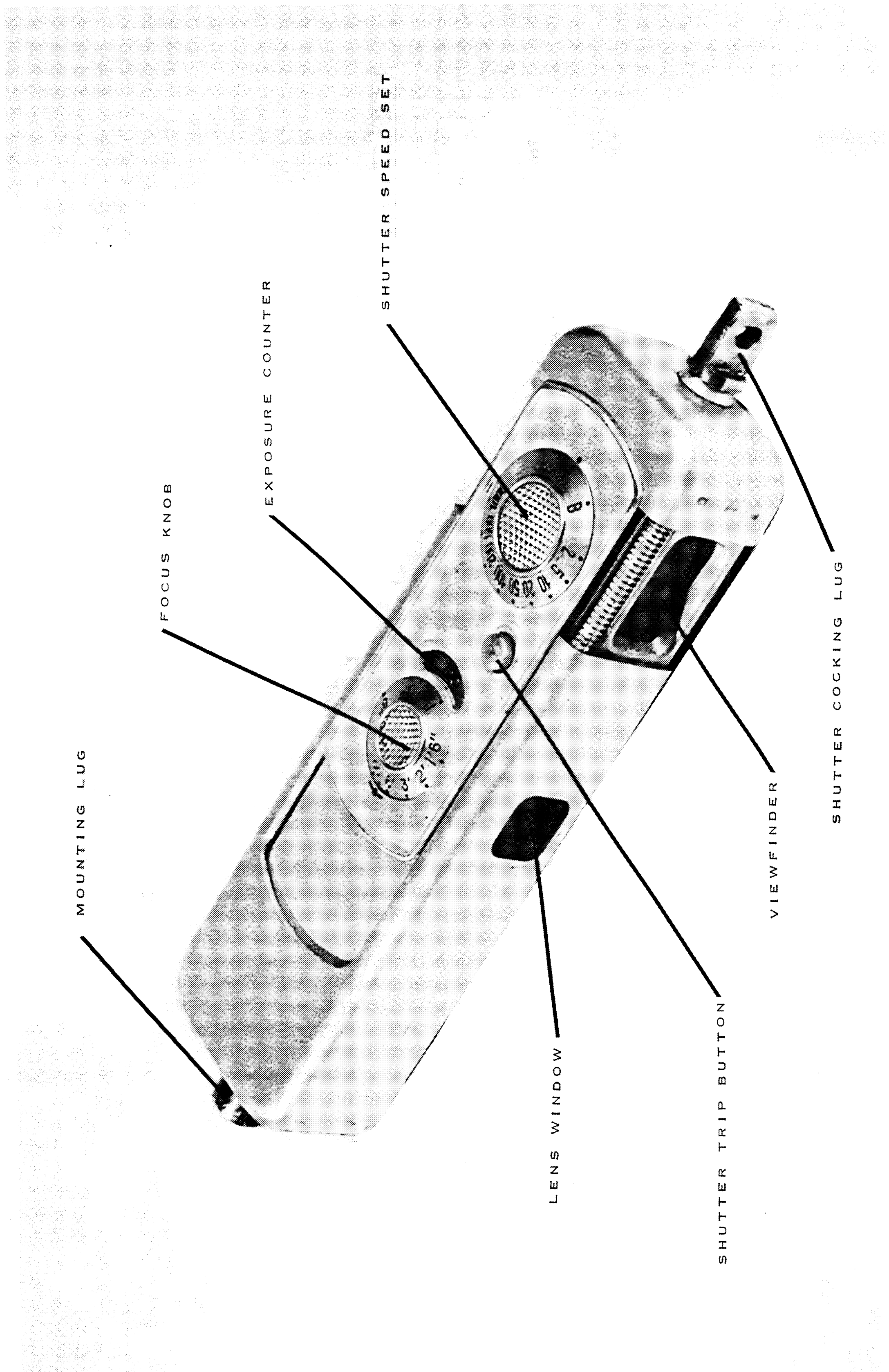
The camera assembly is supported by the power cable which was run along the horizontal crane boom over pulleys. The cable terminates in a control box behind the crane shielding.

The camera control box (Figure VI-7), contains power supplies for the lights and solenoids. Switches are provided for AC power, lights, cocking solenoid, and shutter solenoid. A counter records the exposure number. The ammeter indicates light current, and will show the operator when a light burns out.

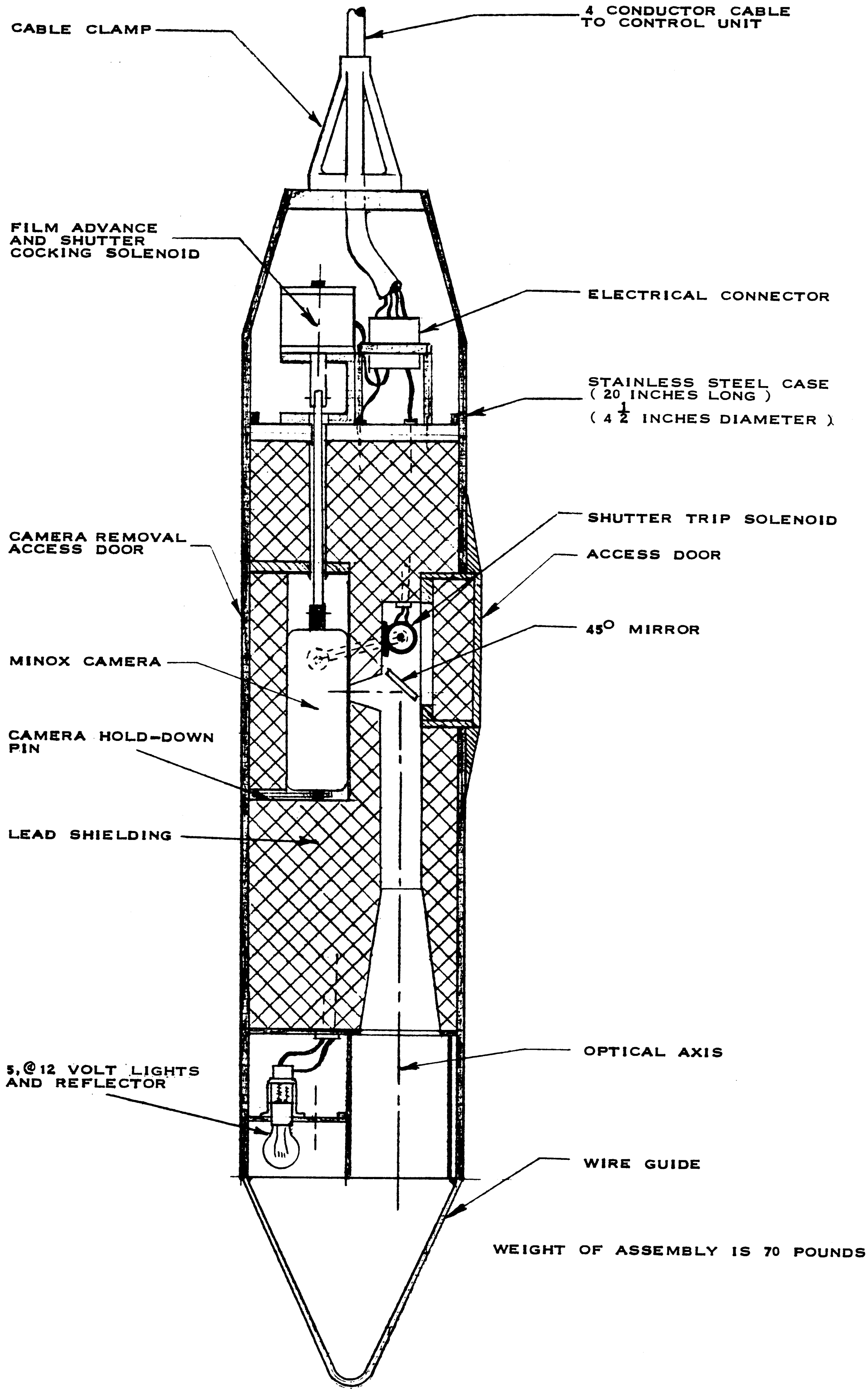
C. WATER LEVEL PROBE

The water level probe used is shown in Figure VI-8. This probe is similar to the water level probe used for Entry No. 15.

The water detector segments (Figure VI-9), contain a $KMNO_3$ crystal and filter paper pulp contained in a plastic tube. Holes in the plastic tube allow water to enter the segment, dissolve the crystal, and color the filter pulp.

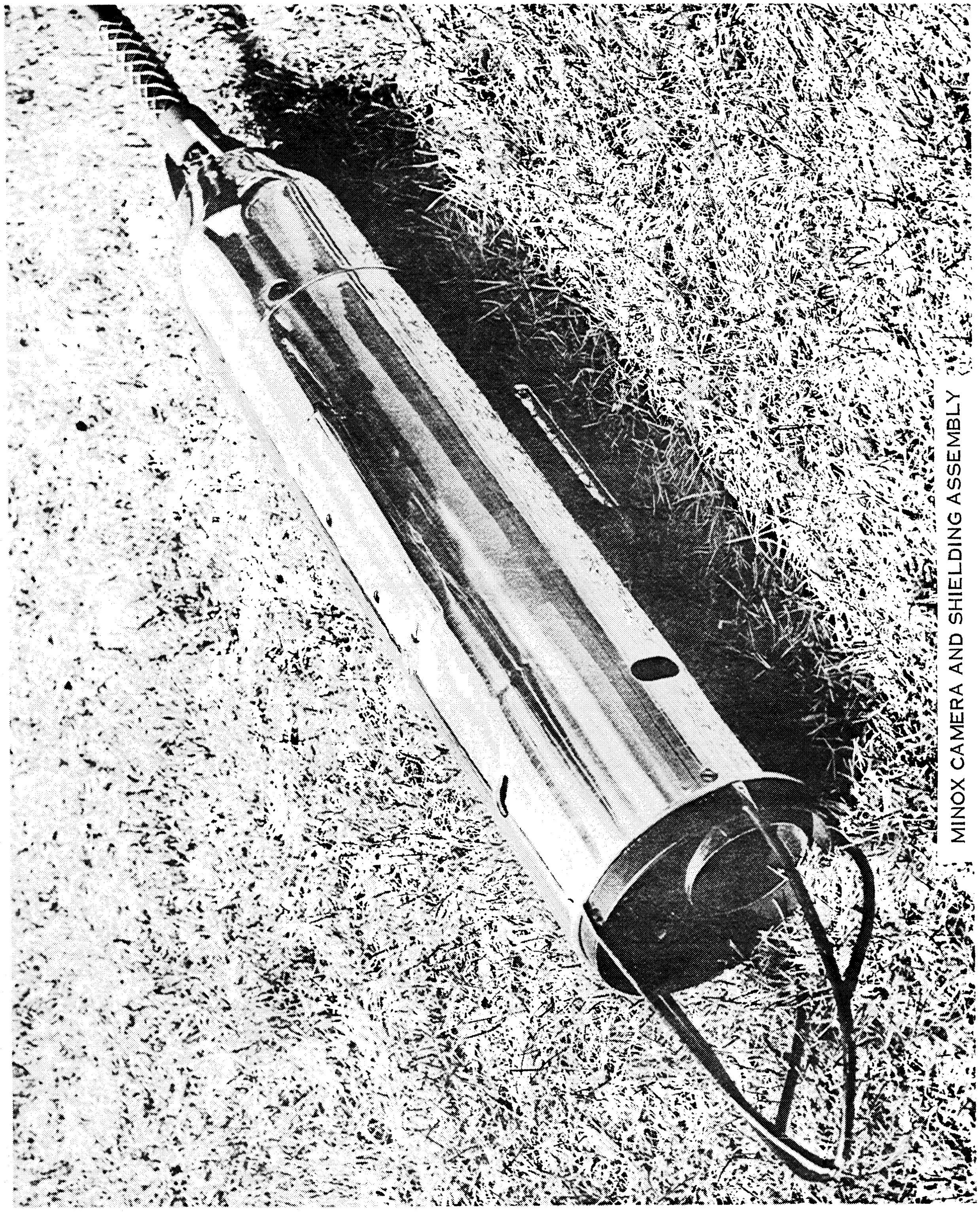


MINOX CAMERA
FIGURE VI-4



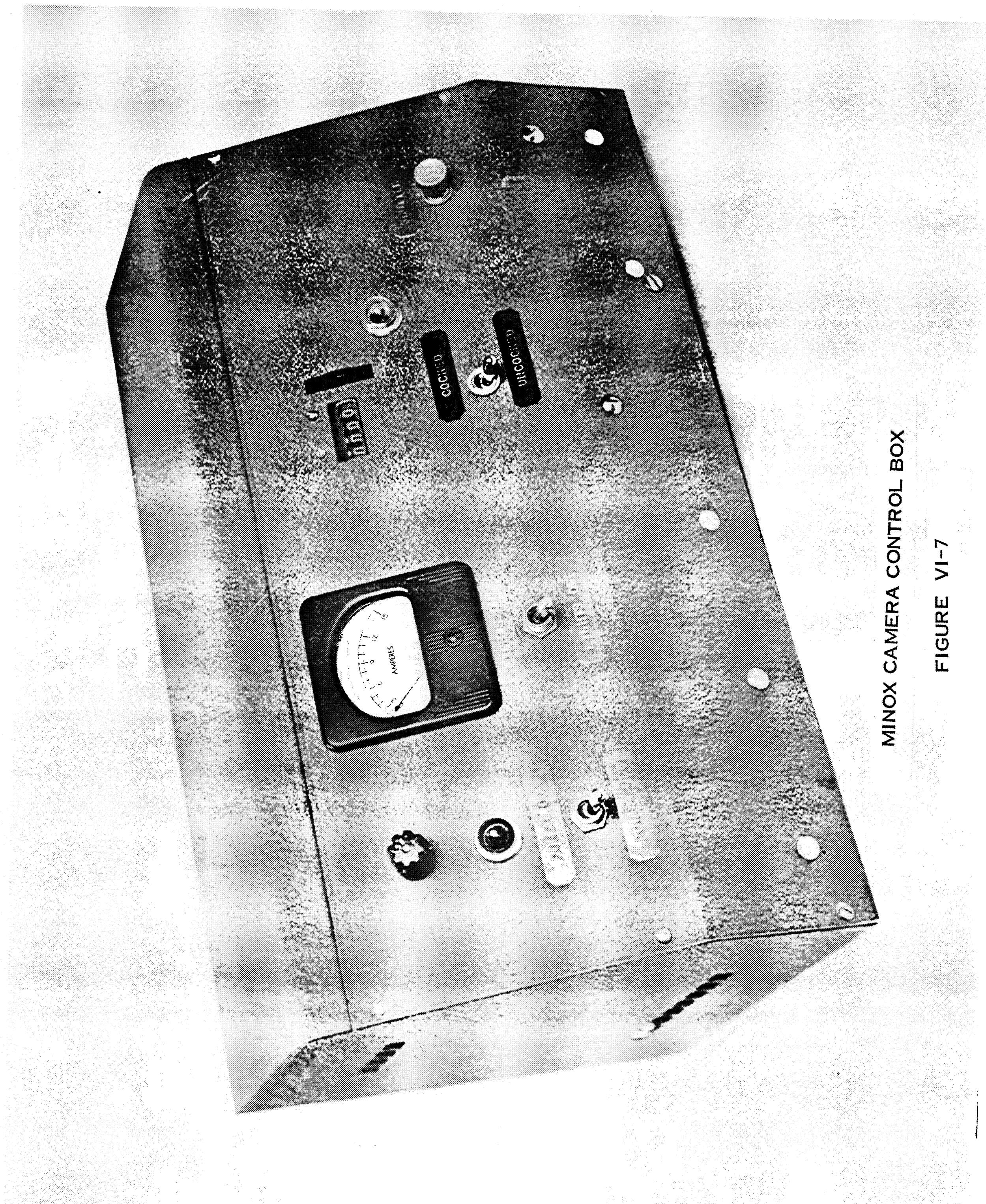
CUTAWAY OF MINOX CAMERA AND SHIELDING ASSEMBLY

FIGURE VI-5



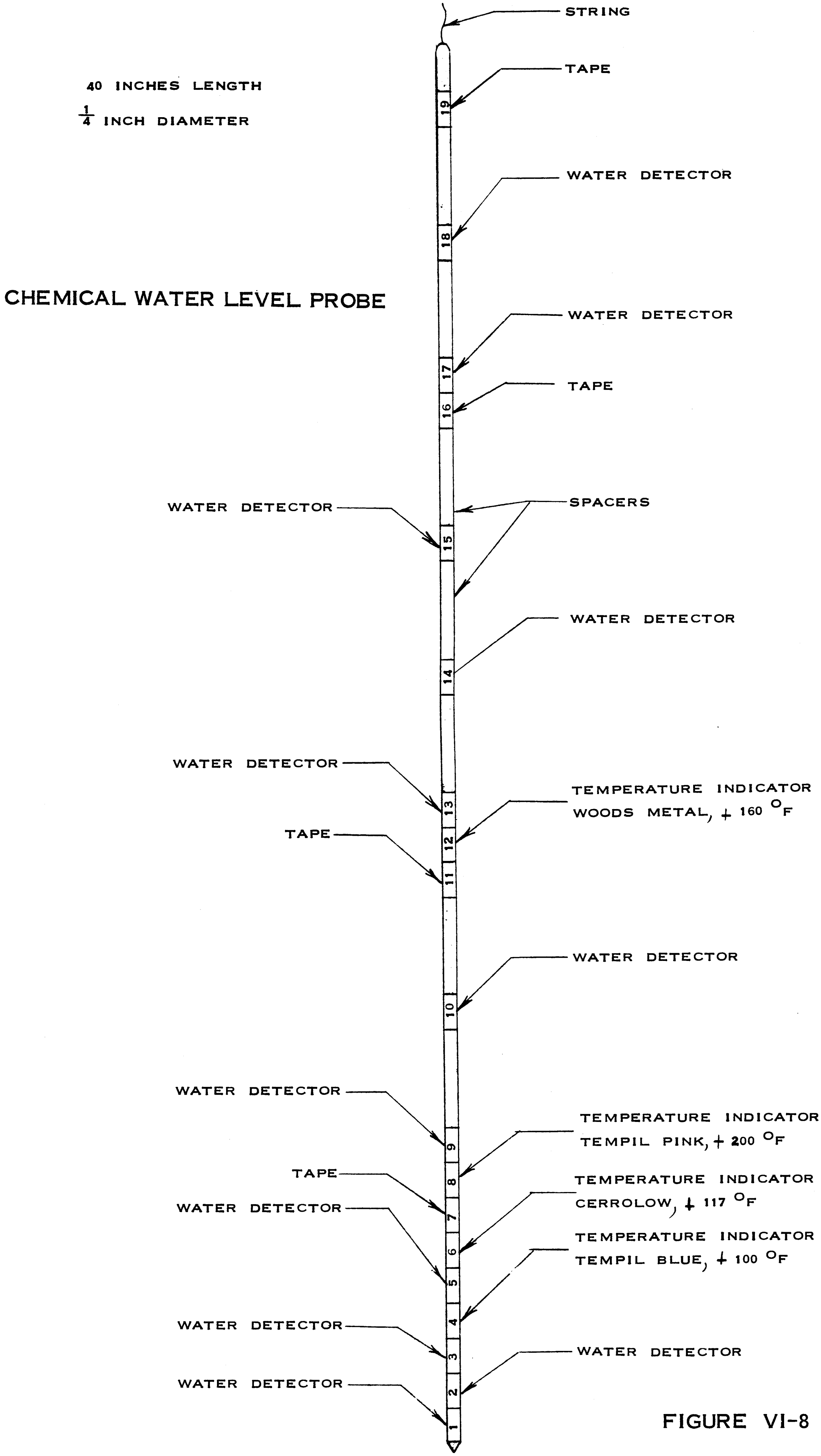
MINOX CAMERA AND SHIELDING ASSEMBLY

FIGURE VI-6



MINOX CAMERA CONTROL BOX

FIGURE VI-7



40 INCHES LENGTH
1/4 INCH DIAMETER
CHEMICAL WATER LEVEL PROBE
STRING
TAPE
WATER DETECTOR
WATER DETECTOR
TAPE
SPACERS
WATER DETECTOR
WATER DETECTOR
WATER DETECTOR
TEMPERATURE INDICATOR WOODS METAL, + 160 °F
TAPE
WATER DETECTOR
WATER DETECTOR
TEMPERATURE INDICATOR TEMPIL PINK, + 200 °F
TAPE
TEMPERATURE INDICATOR CERROLOW, + 117 °F
WATER DETECTOR
TEMPERATURE INDICATOR TEMPIL BLUE, + 100 °F
WATER DETECTOR
WATER DETECTOR
WATER DETECTOR
19
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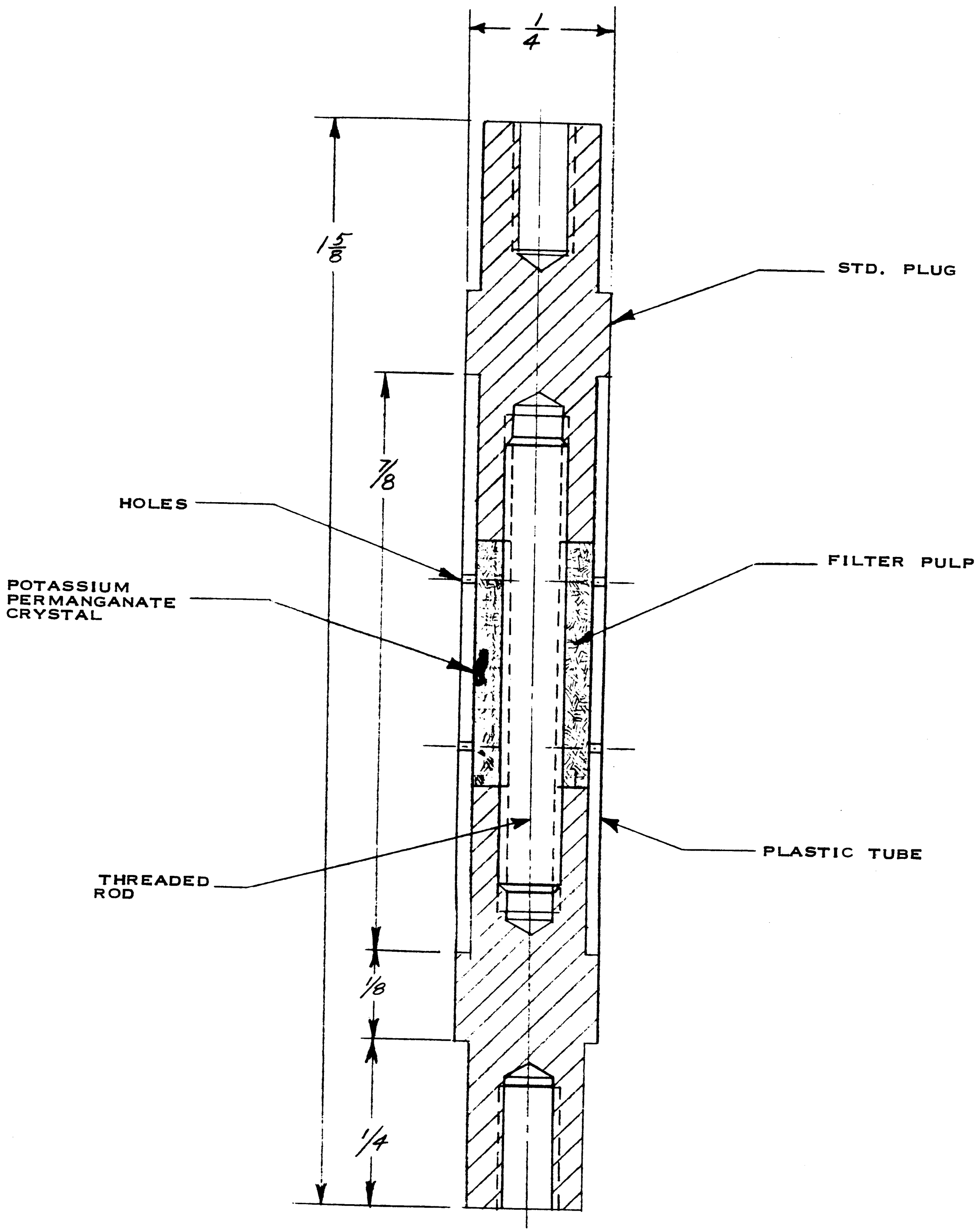
1

FIGURE VI-8



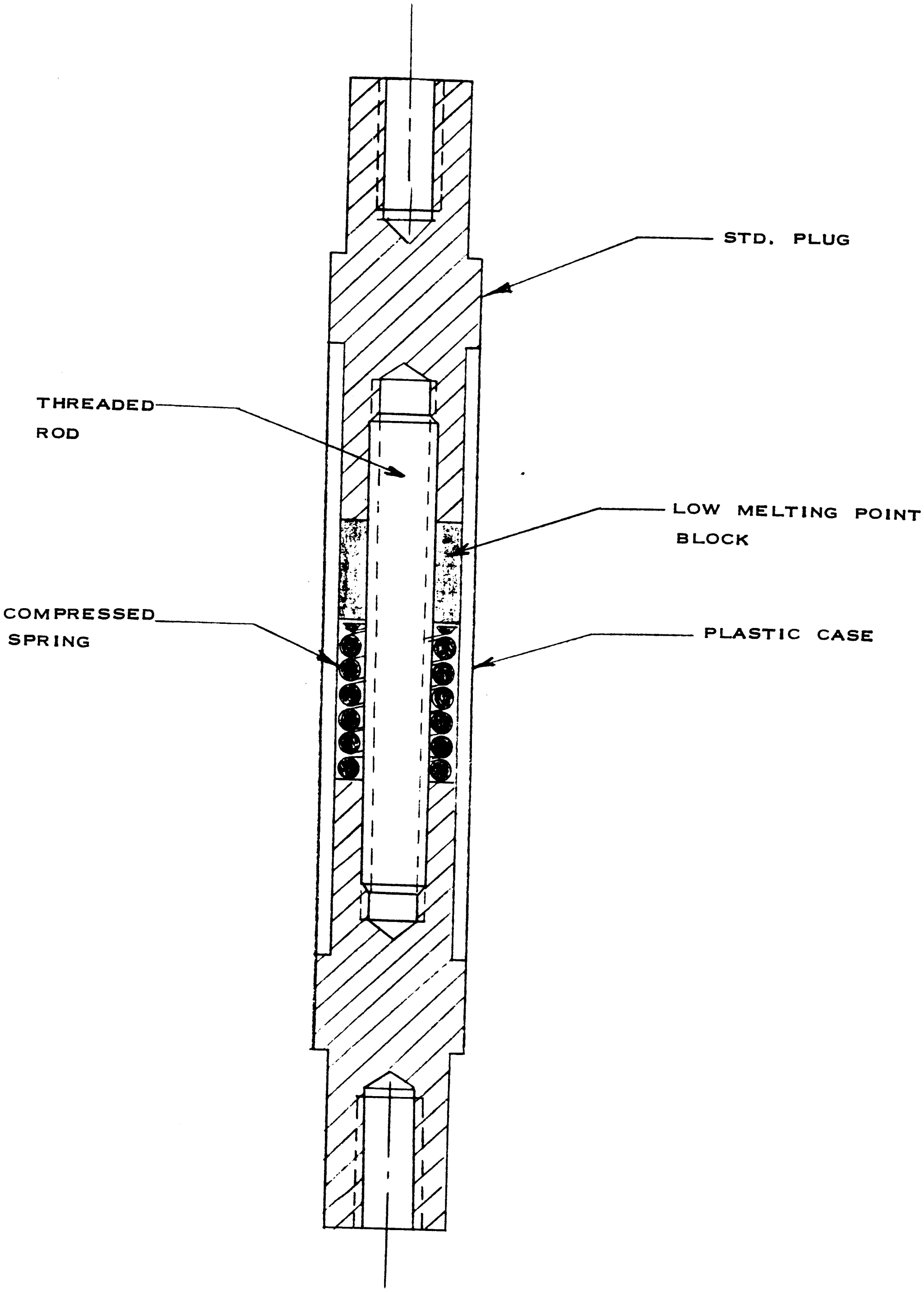
WATER DETECTOR SEGMENT

FIGURE VI-9

The temperature indicators (Figure VI-10), consist of a compressed spring held by blocks which have know melting points. Melting of the blocks allows the spring to expand. Visual exmaination will show spring expansion. Materials with 100, 117, 160, and 200 ^{o}F melting points were provided.

The stainless steel spacers, along with the drop cord, were painted with reflecting paint and reflecting tape was placed around four segments for ease of location in the photographs.

The prcbe weight was seven ounces.



TEMPERATURE SENSING SEGMENT

FIGURE VI-10

April 15, 1961

ADDENDUM A

EQUIPMENT CHECK LIST

The following equipment will be available at the SL-1 Control Point prior to entry and tested for proper operation where applicable.

1. Austin-Western hydraulic crane.

_____ A. Chemical water level probe.

_____ B. Probe line and reel attached.

_____ C. Spring scale in cab.

_____ D. Miniature camera and control box attached.

_____ E. Camera loaded with film.

_____ F. Can spray paint for marking cables.

_____ G. Tools in crane tool box.

1. Knife
2. Screw Driver
3. Electrical Tape
4. Marking Tape
5. Crescent Wrench
6. Electrician's Pliers
7. Heavy Wire Cutters
8. Allen Wrench for Camera

_____ H. Yard stick on shield.

_____ I. Stop watch on head shield.

2. Equipment in Pickup bed.

_____ A. Case for chemical probe

_____ B. Remote handling tools for probes

3. Other

_____ A. Film badges on carriage

_____ B. Film packs on boom

_____ C. Film packs on probes

_____ D. Stopwatch (Supervisor)

_____ E.

_____ F.

_____ G.

April 15, 1961

ADDENDUM B

ENTRY NO. 16 PERSONNEL AND EXPOSURES

Job	Affiliation	Exposure Received
* Michigan Crane Operator	HKF	35 mr/hr
* Michigan Crane Operator	HKF	35
* Health Physics Monitor	Cadre	78
Austin-Western Crane Driver	HKF	70
Austin-Western Crane Signalman	HKF	170
Tower Spotter	HKF	70
Tower Signalman	HKF	85
Probe Operator	Cadre	200
Supervisor	CE	120
Electrician	HKF	100
Probe Recovery	CE	85
Instrumentation Observer	CE	35
Health Physics Observer	CE	100
Observer	CE	85
Observer	AEC	90
Photographer	PP Co	60
Health Physics Monitor	PP Co	60

*Freight Door Opening and Closing

HKF - H. K. Ferguson
CE - Combustion Engineering
AEC - Atomic Energy Commission, Idaho Operations
PP Co - Phillips Petroleum Co.

C·E

COMBUSTION ENGINEERING, INC.

NUCLEAR DIVISION

PO BOX 2558 • IDAHO FALLS, IDAHO

April 17, 1961
OP-RO-3125

Dr. C. Wayne Bills, Technical Director
SL-1 Recovery Operations
Idaho Operations Office
U. S. Atomic Energy Commission
Post Office Box 2108
Idaho Falls, Idaho

Subject: Summary of Results from Entry EP-RO-16, Revision 1
Contract AT(10-1)-967

Dear Dr. Bills:

This letter serves as a summary report of entry EP-RO-16, Revision 1, subject: Procedure for Surveying and Verifying with Photography Water Level and Temperature in the SL-1 Reactor Vessel.

OBJECTIVES

1. To obtain liquid level and determine temperature in the SL-1 reactor vessel.

2. To verify by photographs the location of the water level detector within the reactor core.

3. To obtain additional photographs of the reactor vessel interior.

4. To obtain additional radiation measurements.

SUMMARY OF RESULTS

1. Water Level

A water sensitive chemical probe was lowered into the reactor vessel to a distance of 16 feet 3 inches ± 2 inches below the top surface of No. 8 nozzle flange. The probe, upon removal, indicated no evidence of water. At its maximum depth of penetration, the probe was seated against a hard surface. Weight of the probe, measured with a spring scale, was constant at eight ounces ± one ounce, until it reached 16 feet 3 inches. Distance to the bottom at the center of the reactor vessel is 16 feet 6 inches.

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2. Temperature

Spring loaded chemical temperature detectors incorporated in the probe were not discharged. The set points were:

Tempil Blue	-	100 °F
Grey Cerrolow	-	117 °F
Woods Metal	-	160 °F
Tempil Pink	-	200 °F

3. Position of Probe in Core

Forty-two photographs taken inside the vessel at various exposures and with the probe at various levels show that the probe penetrated the core through No. 8 control rod shroud and that the string was straight and taut at the 16 foot 3 inch level.

4. Radiation Measurements

Data obtained from film dosimeters located on the crane boom and camera are recorded in Table I. The computed dose rates are shown in Table I and Figure 2. The dose rates from the films in the camera have been corrected for the dose received while over the vessel. Evaluation of the data is being made.

The accuracy of film data is approximately ± 20%. The accuracy of film position on the boom was ± 1 inch. Positioning accuracy of the boom over the vessel was ± 3 inches horizontally, and ± 6 inches vertically.

Very truly yours,

COMBUSTION ENGINEERING, INC.

W. B. Allred
ABWR Project Manager

Enclosures - 45

cc: G. E. DeVore

WBA:m

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TABLE I

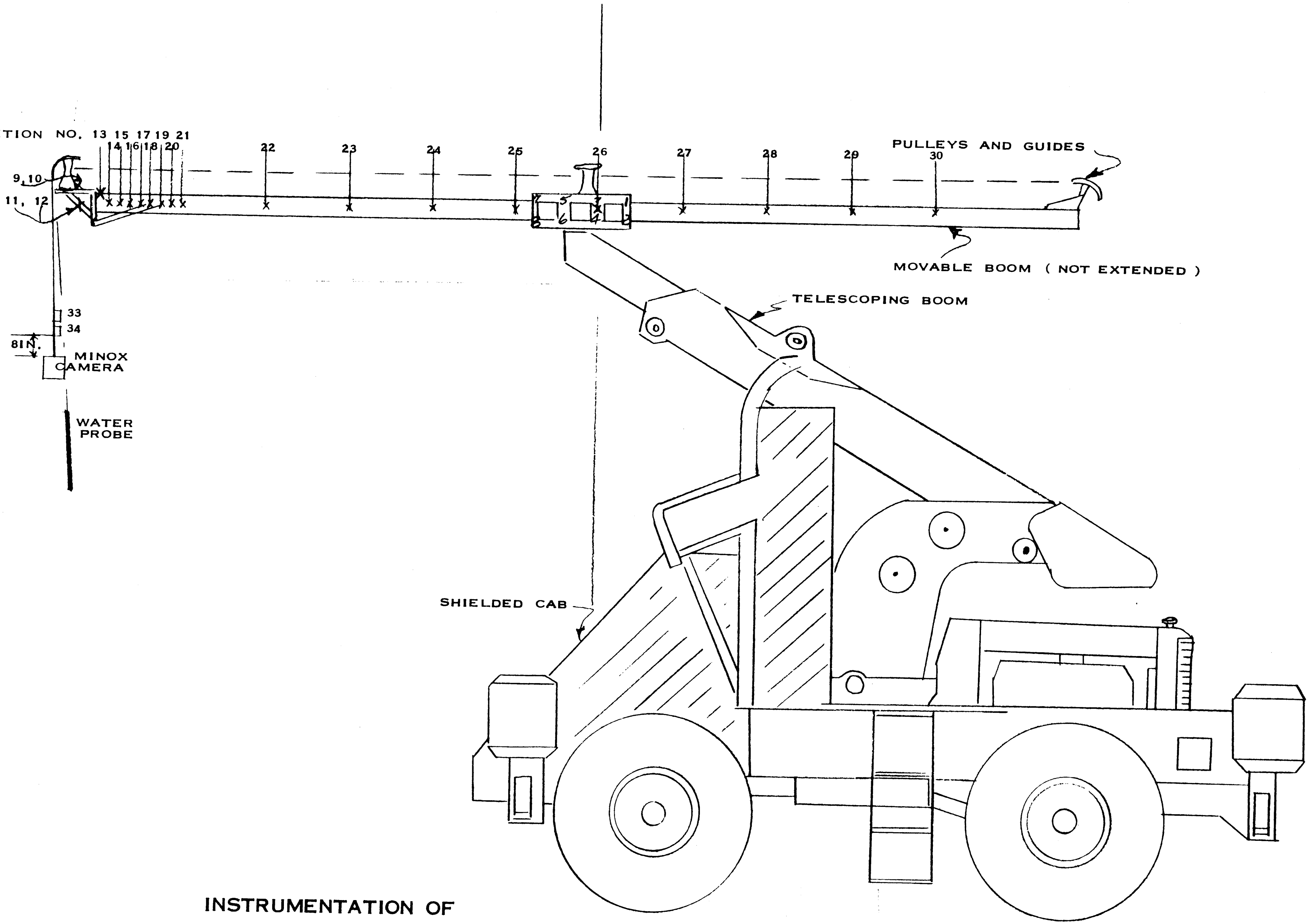
RADIATION DATA FROM ENTRY EP-RO-16

Location	Position	Distance From Cargo Door	Dose - r γ	Dose - r β	Dose Rate r/hr
Boom Carriage at Cargo Door					
17 " outside Building	1	1'5"	11	0	33
	2	1'5"	11	0	33
Aligned w/edge of Cargo Door	3	0	14	0	42
	4	0	14	0	42
12 " Inside Cargo Door	5	1'5"	14	0	42
	6	1'5"	14	0	42
28½" Inside Cargo Door	7	2'4"	16	0	49
	8	2'4"	14	0	42
On Mounting Bracket	9	19'10"	48	50	173
	10	19'10"	46	50	165
	11	19'10"	48	150	173
	12	19'10"	54	170	194
3 " Apart on Movable Boom					
Flush Against Mounting Bracket	13	19'4"	45	0	162
On the Movable Boom (Fig. 1)	14	19'1"	46	50	165
	15	18'10"	42	100	151
	16	18'7"	44	230	158
	17	18'4"	47	200	169
	18	18'1"	46	230	165
	19	17'10"	46	210	165
	20	17'7"	46	175	165
	21	17'4"	46	150	165
2' Apart on Movable Boom (Figure 1)	22	15'4"	48	170	173
	23	13'4"	35	200	126
	24	11'4"	30	380	108
	25	9'4"	28	100	101
	26	7'4"	22	84	79
	27	5'4"	19	74	68
	28	3'4"	19	25	68
	29	1'4"	14	0	50
	30	-1'4"	10	0	36
On Camera Cable (Figure 1)	33	2.5"*	84	NA	420
	34	2.5"	140	NA	820

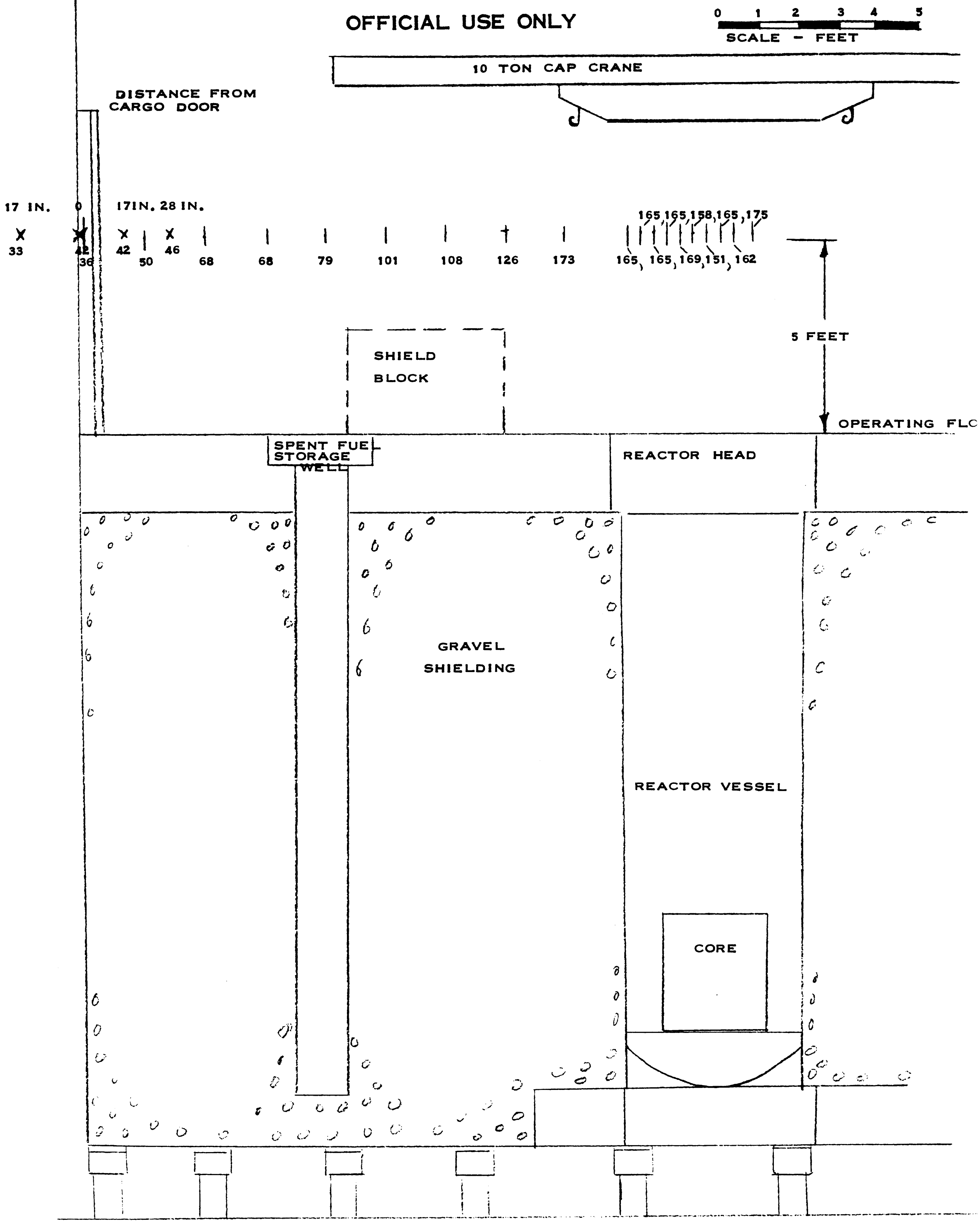
*Distance Below No. 8 Flange

TABLE I (Continued)

NOTES:	Minut
a. Time to position crane in cargo doorway from Administration Building	4.5
b. Time carriage (Positions #1-8) in doorway	19.7
c. Time boom (Positions 9-30) in position	16.7
d. Time camera in hole No. 8	8.5
e. Time removal of crane from cargo door to Administration Building	5
f. Height above operating floor - 5'6".	



INSTRUMENTATION OF
AUSTIN-WESTERN CRANE - DATE OF ENTRY - APRIL 15, 1961
FIGURE 1



ALL DOSES ARE IN R/HR. X INDICATES POINT OF MEASUREMENT. REFER TO TABLE I FOR DISTANCES OF POINTS.

GAMMA DOSE RATES IN THE SL-1 REACTOR BUILDING

DATE OF ENTRY - 15 APRIL 1961

FIGURE 2

CE

COMBUSTION ENGINEERING, INC.

NUCLEAR DIVISION

PO BOX 2558 • IDAHO FALLS, IDAHO

April 20, 1961
OP-RO-3134

Dr. C. Wayne Bills
Technical Director
SL-1 Recovery Operations
Idaho Operations Office
U. S. Atomic Energy Commission
P. O. Box 2108
Idaho Falls, Idaho

Subject: SL-1 Health Physics Data Report No. X
Contract AT(10-1)-967

Dear Dr. Bills

Forwarded for your information is the Health Physics Data Report No. X of the physical facilities at SL-1.

Very truly yours,

COMBUSTION ENGINEERING, INC.

W. B. Allred
ABWR Project Manager

WBA:RLL:jb

Enclosures: (45)

cc: Mr. G. E. DeVore

DR-RO-16

SL-1 HEALTH PHYSICS DATA REPORT NO. X

April 20, 1961

R. L. Layfield

U. S. Atomic Energy Commission

Contract AT(10-1)-967

COMBUSTION ENGINEERING, INC.
Nuclear Division

Idaho Falls Idaho

DR-RO-16

HEALTH PHYSICS DATA REPORT NO. X

I INTRODUCTION

This is the tenth Combustion Engineering, Inc. Health Physics Data Report of SL-1 Recovery Operations. It covers the period of April 3 through April 15, 1961.

II SUMMARY

A. Radiation surveys show noticeable reductions in isodose lines at all levels.

B. Air samples continue to show concentrations less than 1.0×10^{-11} uc/cc at the SL-1 perimeter fence.

C. Strontium 90 analyses completed on soil samples collected on February 17th resulted in a specific activity of 6×10^4 d/m/gm.

III RADIATION SURVEY (Figure 1)

A. Isodose Survey

A radiation survey was conducted on April 14, 1961 for the purpose of establishing isodose lines within the SL-1 Site. Measurements were also taken at established points along the perimeter fence to determine radiation decay. There was a noticeable decrease at all isodose lines. A comparison to the isodose lines determined on March 30th and shown in Health Physics Data Report IX shows that the 200 mr line has moved ten feet closer to the reactor building.

IV AIR SAMPLES

The air samples taken with the Hi-Volume air samplers positioned at the fence perimeters continue to show very low concentrations ($< 1.0 \times 10^{-11}$ μc/cc) of radioactive iodine and other fission products, i.e., Zr^{95}, Nb^{95}, Ru^{106}, Cs^{137}, $Ce^{141-144}$.

V SOIL SAMPLES

The strontium 90 analyses of the soil samples taken on February 17th have now been completed. A high specific activity of 6×10^4 d/m/gm was revealed in sample No. 16. Figure 2 shows the location and the strontium 90 concentration for each sample.

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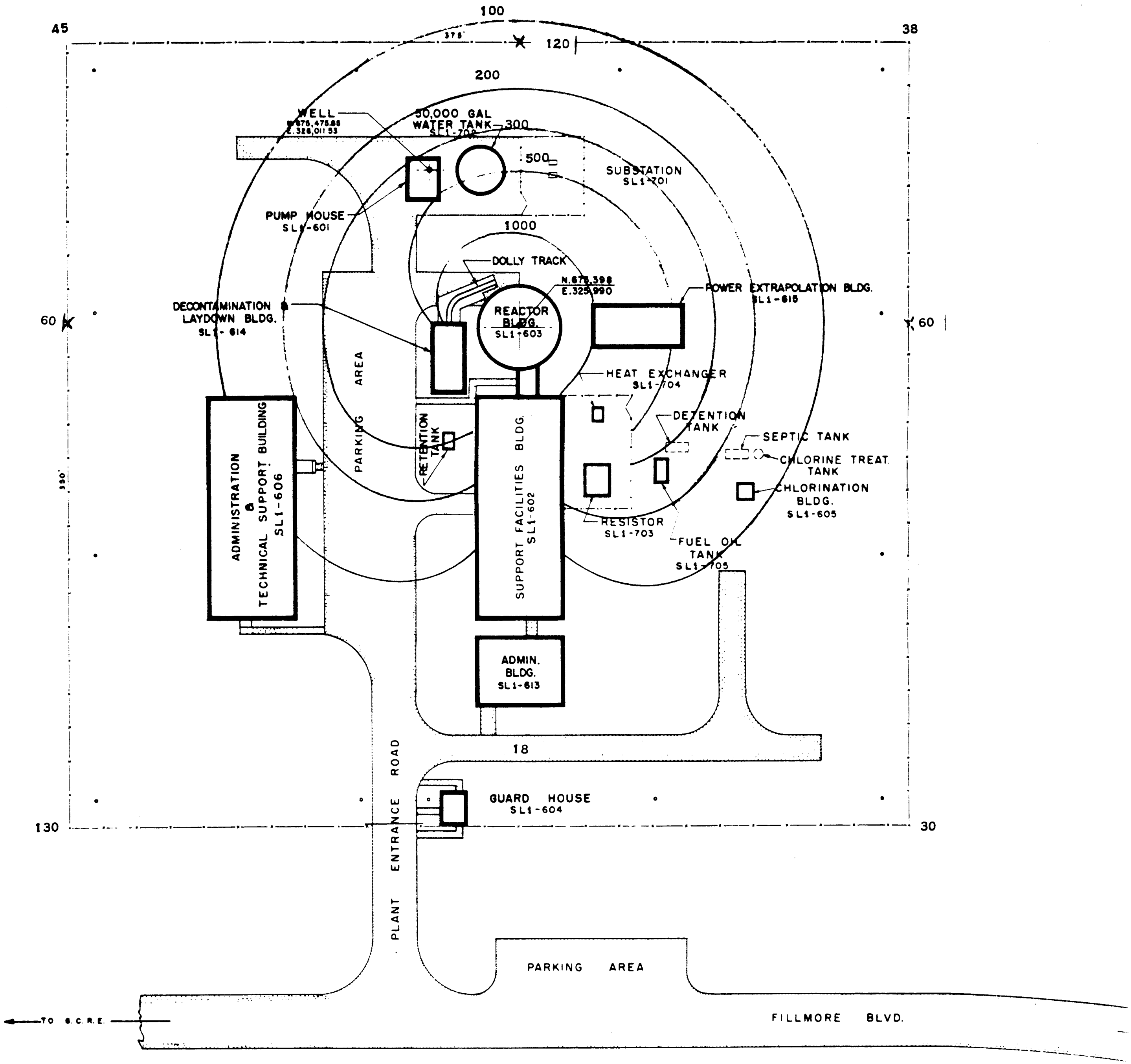
ALL READINGS ARE IN MR
INSTRUMENT, IDO HP SR JUNO, 1247



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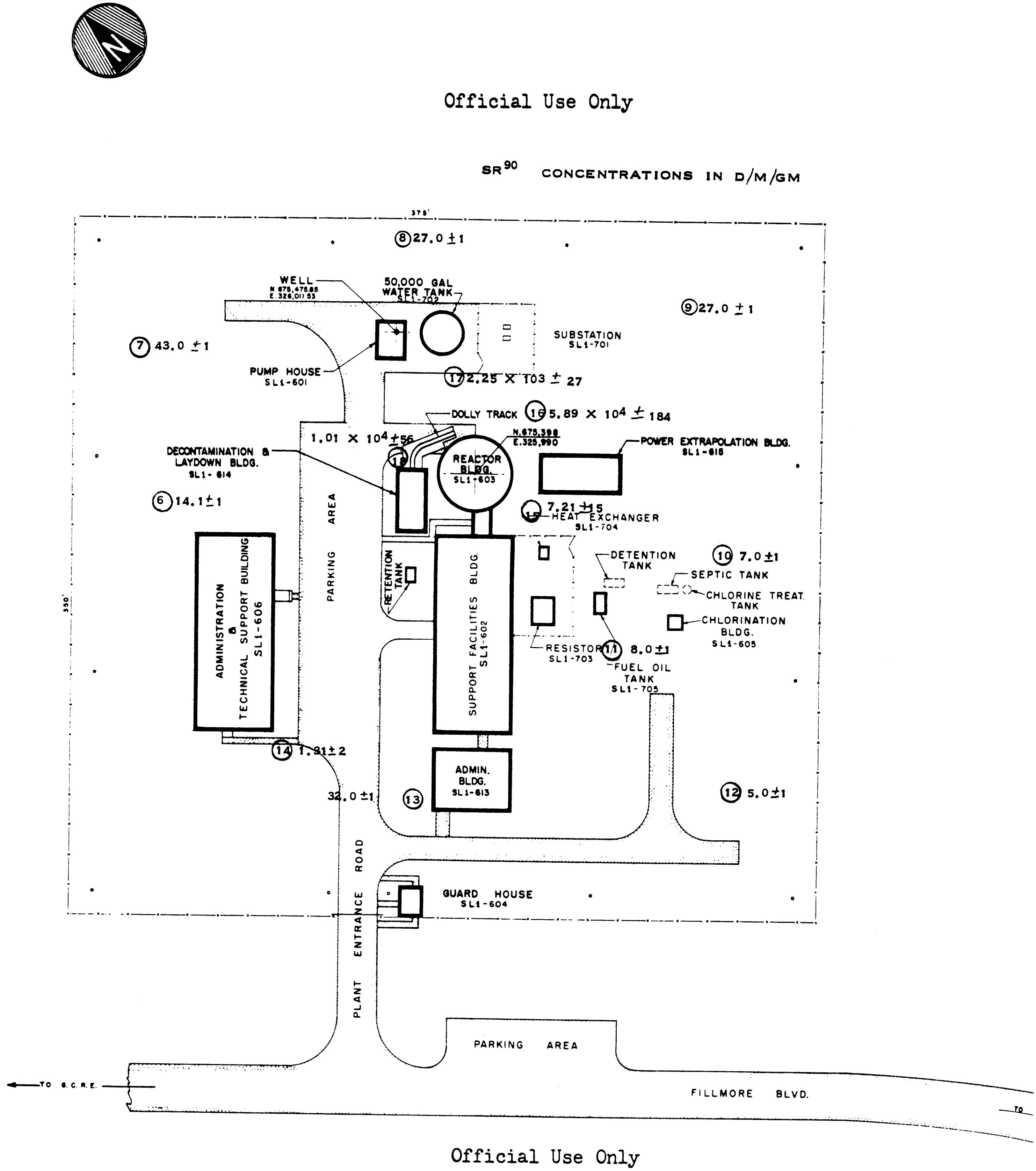
SL-1 ISODOSE SURVEY, APRIL 14, 1961

FIGURE 1



SL-1 SITE
SOIL SAMPLE LOCATIONS & RESULTS
FIGURE 2

COMBUSTION ENGINEERING, INC.
SL-1 RECOVERY OPERATION

SUMMARY OF ENTRIES MADE INTO SL-1

Date of Entry	Entry No.	Objective	Result
January 8, 1961	1	To Remove Third Body	Body Recovered
	2	Alternate Body Recovery	Not Used
January 11, 1961	3	To Remove Key Contract Documents To Perform Smear & Instrument Survey of the Control Room, Maintenance Shop, and General Office	Documents Removed and Surveys Made
January 9, 1961	4	To Establish Procedure for Closing Cargo Door	Installation of a Movable Door
January 17, 1961	5	To Perform Site Radiation Survey - 2nd Survey - To obtain radiation measurements outside the SL-1 Buildings	Establishment of a Repetitive Procedure
January 17, 1961	6	Installation of Gamma and Neutron Monitor System under and around the Reactor Building for the purpose of furnishing an emergency warning system in the area	System Successfully Installed
January 25, 1961	6A	To Install Neutron Monitoring Package	Back-up Neutron Monitoring Package Installed
	7 (Transmitting 5 and 6)		
January 23, 1961	8	To Take Motion Pictures of Top Head of SL-1	100 Feet of Motion Pictures Showing Reactor Head Taken
January 22, 1961	9	To Take TV Pictures in the SL-1 Tank	Unsuccessful - Equipment Failure
January 26, 1961	9, Revision 1	To Take TV Pictures in the SL-1	Unsuccessful - Equipment Failure

COMBUSTION ENGINEERING, INC.
SL-1 RECOVERY OPERATION

SUMMARY OF ENTRIES MADE INTO SL-1

Date of Entry	Entry No.	Objective	Result
February 22, 1961	9, Revision 2	To Take Motion Pictures of the SL-1 Core	140 Feet of 16 mm Movie Film Inside Reactor Vessel Taken
	10	To Take Liquid Level in the SL-1 Reactor Vessel	Not Used - Revised February 27, 1961
February 28, 1961	10, Rev. No. 1	To Take Liquid Level in the SL-1 Reactor Vessel	Sonic Level Probe Dropped 11'4" No Water
	10	Chemical Analysis to be done on SL-1 Reactor	Not Used - Sample Not Secured
February 2, 1961	11	Installation of Fission Chamber System in SL-1 Beam Hole, Tasks I and II	Neutron Detector System Successfully Installed
Various	12	Daily Check-Out of Monitoring Instrumentation Located Under the SL-1 Reactor Building	Establishment of a Repetitive Procedure
March 15, 1961	13	Installation of Additional Radiation Alarms	Installation of Visible and Audible Alarms for Personnel During Entries
March 16, 1961 March 17, 1961	14 14	Television Viewing of the Interior of the SL-1 Reactor Vessel - 1. To obtain additional views of the vessel interior for a more accurate assessment of core geometry - 2. To confirm the estimated position of No. 9 Control Rod. - 3. To view light reflections, if any, for water level determination. - 4. To obtain additional radiation information	Unsuccessful Entry - No Pictures 500 Feet of movie film made of conditions inside reactor vessel

COMBUSTION ENGINEERING, INC.
SL-1 RECOVERY OPERATION

SUMMARY OF ENTRIES MADE INTO SL-1

Date of Entry	Entry No.	Objective	Results
March 29, 1961	15, Revision 1	Surveying Water Level & Temperature in the SL-1 Reactor Vessel -1. To obtain liquid level in the SL-1 reactor vessel. -2. To determine the temperature within the reactor vessel. -3. To obtain additional radiation information.	Probe Lowered 1'6" Below Core - No Water. Temperature Maximum 98 ^{o}F
April 15, 1961	16	Surveying Water Level in SL-1 Reactor Using Miniature Camera	Probe lowered 16'3" below No. 8 Flange with Pictorial Verification - No Water
April 15, 1961	16, Revision 1	Surveying Water Level in SL-1 Reactor Using Miniature Camera -1. To obtain liquid level and verify temperature in the SL-1 reactor vessel. -2. To verify the location of the water level detector within the reactor core. -3. To obtain additional photographs of the reactor vessel interior -4. To obtain additional radiation measurements.	Revised After Entry to Reflect Changes During Operation
April 20, 1961	17	Taking Dry Particle Samples from the SL-1 reactor vessel for chemical analysis. -1. To obtain sufficient quantities of particles from the reactor vessel for chemical analysis -2. To obtain additional radiation	Material Secured for Analysis

COMBUST ENGINEERING, INC.
SL-1 RECOVERY OPERATION

SUMMARY OF ENTRIES MADE INTO SL-1

Date of Entry	Entry No.	Objectives	Results
April 25, 1961	17, Revision 1 Addendum 1	Analysis of Material Vacuumed from the SL-1 Reactor Vessel	Material Being Analyzed in Chemical Processing Plant
	18	Draining SL-1 Demineralized Water Storage Tank and Hotwell -1. Remove water from demineralized water (1000 gal.) storage tank. -2. Remove water from Hotwell storage tank. -3. Obtain sample of drained water for gross activity analysis.	Proposed
May 2, 1961	19	To Take Additional Movie Pictures of Reactor Head Region Including Control Rod Thimble - Traverses of the reactor head & surrounding area within shield blocks will be made and additional movie film will be taken.	175 Feet of Movie Film Obtained in a Schematic Traverse of Reactor Head
May 11, 1961	20	Minox Pictures of Reactor Core Thru Nozzle No. 8 - The Minox camera with a suitable mounting to permit tilting, rotating, and positive indexing of the camera will be lowered through Nozzle No. 8 for taking still pictures of the core.	39 photographs obtained which show condition of 40% of core. Greater detail shown in these pictures.
May 17, 1961	21	Remove Control Rod thimble to Clear No. 4 Nozzle - Grappling tongs or other suitable device suspended to the Austin-Western crane boom will be used to engage and move the control rod thimble from No. 4 nozzle.	Shield plug removed from No. 4 Nozzle and 325 feet of film taken thru No. 4 of the inside of vessel showing greater destruction than previously obtained.

COMBUSTION ENGINEERING, INC.
SL-1 RECOVERY OPERATION

SUMMARY OF ENTRIES MADE INTO SL-1

Date of Entry	Entry No.	Objective	Results
May 19, 1961	22	Minox Pictures of Core Thru Port No. 4 - The Minox camera with a suitable mounting to permit tilting, rotating, and positive indexing of the camera will be lowered through Nozzle No. 4 for taking still pictures of the core.	40 pictures of the inside of the reactor vessel taken. Shows bett detail of core destruction. No s nificant change in radiation leve
Week of May 22	23	Collect Additional Samples - The vacuum cleaner will be lowered through Nozzle No. 8 to the top of the core structure for collection of debris.	Proposed
Week of May 29	24	Determine Radiation Sources in Reactor Operating Room - A shadow shield consisting of 1¼" lead plate will be suspended over the reactor head from the crane boom. Radiation dosimeters will be placed over and under the plate for direct core readings and for reading of radiation from sources other than the core.	Proposed

COMBUSTION ENGINEERING, INC.
SL-1 RECOVERY OPERATION

SUMMARY OF ENTRIES MADE INTO SL-1

OTHER ENTRIES

Period Covered	Purpose	Number of Entries
January 3 thru January 10	Original Emergency Operations	90
January 11 thru May 20	Health Physics Surveys	20
January 11 thru May 20	Instrument Checks	35
January 11 thru May 20	Maintenance of Equipment & Plant	29
January 11 thru May 20	Observations	6
January 11 thru May 20	Record Recovery	11
January 11 thru May 20	Equipment Recovery	15
January 11 thru May 20	Operational Entries (Numbered)	22
TOTAL ENTRIES - JANUARY 3 THRU MAY 20		228